STUDIES ON CONFORMATION IN RELATION TO MILK PRODUCING CAPACITY IN CATTLE[1]

II. The Personal Equation of The Cattle Judge

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Progress of the dairy cattle industry depends in the last analysis on men. If these men are gifted with that supernatural power by which they can choose the best from the best, progress toward the desired goal will be rapid. But should these men be misfits, ever making the undesirable choice, progress will be nil or worse. It is the man equation which counts.

The history of dairy cattle breeding is honeycombed with the personal equation of the men who laid the foundation of our modern industry. It is in fact to the combined ideals of the breeder and showman of the past that we owe the form and conformation of the cattle of today. As originally conceived these ideals naturally varied. The animal, at first taken as a whole, came more and more to be regarded as composed of parts, each with a definite function. As a further development it became evident that these functions were co-related and that conformation of one part of the body might indicate the functioning of another part. The paramount importance of determining these co-relations between body conformation and milk yield was recognized early. Point by point the characters of the good cow as distinguished from the poor producers were picked out and segregated in men's minds. Their origin was diverse, one appearing in this community, the other appearing miles away. In its earliest beginning in the eighteenth century, we owe one of the first points of cattle judging to an obscure section of Scotland;

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later the Jersey Isle contributed others, and the Frenchman, Guénon, called attention to the escutcheon. Thus to each dairying locality is the modern dairyman indebted for some information on the selection of dairy animals. Most of the points were passed down from generation to generation by word of mouth. In this stage the ideas were plastic, being shifted for truth and molded in form by each generation. It is to Le Contour that we owe the collection and rounding out of the early ideas into a complete whole. He did his work well, for, if we examine the score card of the show ring or the text book, little visible change has been made from that which he originally published save in the most minor points.

Today we are face to face with much the same problem that Le Contour tried to solve with his score card. The opportunities for progress are better, however. Whereas in his day the milk scales were almost unknown, today they are so common and inexpensive that some sort of record should be available for most cows. Dependence no longer need be placed in the judgment of the man in determining the best from the poorest. Unfortunately the wily craftsman from whom it is sometimes necessary to buy has shaken the confidence in such records, unless they are certified by some such means as the advanced registry. The problem consequently becomes nearly as acute as in the former days when lack of instruments made conformation the basis of most selection of dairy cattle. Analytically considered, however, the dairy cattle industry is in a more advantageous position. In the days of its beginning the points of conformation were not subject to any adequate test of their validity both because of the lack of suitable records and because of the lack of proper methods. Naturally many spurious points with little or no relation to milk yield made their appearance among the truly legitimate characters by which the good cows with adequate production at the pail could be selected from the poor producers. Today both the data and the methods are available to properly test the true worth of the points of conformation.

The American Jersey Cattle Club has collected a large series of data on the scores of cows making their advanced registry.

These records have been made available for analysis by this laboratory through the kindness of Mr. Gow.[2] These records have already been analyzed[3] to show the value of the different points as indicators of the cow's ability in the 365-day test. Briefly the points of conformation which bear more particularly on milk yield are the total score of the cow or what might be called the cow taken as a whole; the character, size and elasticity of milk veins; the size and quality of the whole udder; the size of the rear udder; the shape and size of the paunch; the general appearance of the cow; the thighs flat and well cut out, and the length of the rump. The other points are of such small worth as indicators of the milk producing capacity of the cow that they may be neglected without any appreciable error.

It was further shown that if we compare the relative worth of conformation as a whole (total score) or of any of the individual points as a measure of 365-day milk yield with a milk yield of short duration as a measure of the 365-day production it is found that a milk record of Holstein-Friesian cows even though it was only taken for seven days was about two and one-half times as good an indicator of the cow's ability as were any of the physical points of conformation.[4]

Pausing to consider briefly these facts we see that a seven-day test might be considered as an objective test whereas the value of the points on conformation are a subjective test for the cow's producing ability. That is, the seven-day test is simply dependent on the reading of the scales that weigh the milk, whereas

[2] The author wishes to express his personal appreciation for this coöperation.

[3] Gowen, John W., 1920. Conformation and its relation to milk producing capacity in Jersey cattle. Jour. Dairy Science, vol. iii, no. 1, 1–32.

[4] It may be argued that since these data are for advanced registry cattle they are not of general application. This may be true in part. In a comparison of the size and elasticity of milk veins with milk yield Aldrich and Dana (Aldrich, A.M., and Dana, J.W. 1917. The relation of the milk veins system to production. In Bul. 202, Vermont Agricultural Experiment Station, p. 1–24, fig. 3) showed essentially the same correlation coefficients on 600 cattle selected presumably at random which were shown in the author's former paper on scores of these organs and milk yield. Such being the case it would appear reasonable to suppose that the relations as above deduced from registry of merit cattle are not materially different from those actually found in dairy cattle as a whole.

the use of a scale of points to judge a cow for milk yield depends not on any external scale but on the mental processes or mental ability of the judge to so balance his cuts as to show the true worth of the cow. From this it follows that the conformation of the cow as a measure of milk yield would in all probability be subject to the personal bias of the judge. Analysis of the data on this point shows that such is in truth the case. In table 1 are given the constants for the average score and milk yield as calculated for each of the 19 different judges. These judges are selected to include those which had scored 25 or more cows with known milk yields. The probable errors are calculated by the ordinary method. It is realized that this method makes it subject to some error, causing the probable error to be too low in amount. The judges are indicated by a code number of this laboratory.

Examination of the mean score for each judge as given in table 1 shows that considerable difference of opinion exists. If this mean score is compared with milk yield, the differences become even more marked. Thus judge 1 gives his cows a score of 91.9 when these cows' average milk yield is 7645, whereas in the opinion of all the judges, cows of this milk yield should be scored only 90.1. Judge 58 gives cows whose milk yield was 7538 a score of only 85.5 on the average. If these two judges' opinions be compared it is seen that on cows of approximately the same milk yield they have a difference of 6.5 ± 0.6 points on score. Other comparisons bring out similar results. Where such differences exist there must be a corresponding diversity of opinion in the minds of judges of dairy cattle as to what score should be given to animals of a given milk yield. This, of course, does not say that the judges who score all of their cattle high for a given average of milk production are better judges of milk yield from conformation than those who score their cattle lower. In fact the reverse may be the case. The only difference is that the mental scale of the value of conformation for milk yield differs in men, causing the resulting score on cows of the same milk yield to be lower or higher in accord with the relative level of their mental scale. The judges 1 and 58 illustrate such a condition of affairs, judge 58

scoring cattle actually though not significantly better for milk yield than judge 1, although no. 58 has a lower scale for scoring.

If the relative variation of score and milk yield between these different judges is studied, the high score is seen to be associated with high milk yield and low score with low milk yield. Thus even between these judges there remains after deducting the personal equation some association between milk yield and total

TABLE 1

Mean score and milk yield of Jersey registry of merit cattle as scored by nineteen different judges

SCORER	MEAN SCORE	MEAN MILK YIELD
1	91.9±0.2	7645±106
2	91.5±0.3	8095± 87
6	90.6±0.3	6905±143
20	91.8±0.4	8320±219
31	91.1±0.1	7847±108
33	92.0±0.2	8063±108
37	89.2±0.4	8245±192
47	90.4±0.3	7455±167
51	91.0±0.3	7580±194
52	89.2±0.4	7115±201
58	85.5±0.5	7538±215
59	89.4±0.3	8147±159
76	90.4±0.5	8156±210
80	91.7±0.4	7380±227
84	85.7±0.6	7833±153
89	91.8±0.4	8385±205
102	90.4±0.3	7144±160
117	87.2±0.4	7286±132
118	91.5±0.3	7000±107
Average.....	90.1	7691

score. All correlations are very low and their probable errors so great, due to lack of numbers, that it is doubtful if comparisons between judges should be considered as more than indicative, however.

The amount of variation for the total score and amount of milk is shown for each of the judges in table 2.

No particular association is shown to exist between the variation of each judge in his total score and the variation of the cattle

he judged as to their milk yield. That is because one judge was scoring a group of cows highly variable in their milk yield it was no sign that his scoring of these cattle would show more variation than would the scores of a judge rating a group of cattle whose milk yield was less variable. In fact, it was equiprobable that the scores of the two judges would be equal in their variation.

TABLE 2

Standard deviations of total score and of milk yield for Jersey registry of merit cattle as scored by nineteen different judges

JUDGE	STANDARD DEVIATION SCORE	STANDARD DEVIATION MILK
1	3.66±0.16	1745±74
2	4.91±0.19	1576±62
6	3.30±0.24	1381±102
20	3.50±0.27	2024±155
31	2.48±0.10	1944±76
33	3.19±0.13	1908±76
37	3.76±0.25	2028±135
47	3.98±0.23	2011±118
51	2.19±0.21	1440±137
52	3.25±0.30	1521±142
58	3.87±0.36	1629±152
59	2.75±0.18	1678±112
76	4.14±0.35	1761±148
80	2.82±0.27	1681±160
84	5.67±0.43	1420±108
89	2.73±0.26	1552±145
102	3.24±0.20	1820±113
117	4.02±0.30	1264±93
118	2.95±0.19	1195±76
Average.....	3.50	1612

If comparison is made between the data of tables 1 and 2 it is clearly seen that each judge has his personal scale for judging cattle. Thus, if we compare the two judges 20 and 31 it is found that these judges scored groups of cattle quite similar in milk yield, in fact differing only by about one-twentieth of its total amount. The milk yields of the two groups of cows were nearly the same in variation. The average score in each case was practically the same but the score of judge 31 was about one-third less than the score of judge 20.

Some likenesses are shown to exist between the way in which the judges score different groups of cattle. Thus the judges who give the higher average scores to their cows have a less variation of their scores between cows than the judges who give their cattle lower scores even though the milk yields of these cows are more variable.

No particular relation exists between the average milk yield and the variation of the score.

TABLE 3

Correlation between score and milk yield for Jersey registry of merit cattle as shown by nineteen different judges

JUDGE	CORRELATION COEFFICIENT BETWEEN SCORE AND MILK
1	0.174±0.058
2	0.241±0.052
6	0.222±0.099
20	0.578±0.072
31	0.097±0.055
33	0.428±0.046
37	0.413±0.078
47	−0.098±0.082
51	0.228±0.128
52	0.205±0.127
58	−0.077±0.131
59	0.160±0.092
76	0.417±0.098
80	0.170±0.131
84	0.614±0.067
89	0.405±0.111
102	0.363±0.076
117	0.027±0.104
118	0.106±0.089
Average	0.246

The foregoing results all point to the conclusion that judges differ in the mental scale by which they judge cattle. It now remains to be shown if the mental scale of each judge is equally adequate in placing the different cows properly as regards milk yield and butterfat percentage. The data of table 3 furnish the information necessary for such a comparison.

Table 3 shows that of the nineteen men who judged different groups of Jersey registry of merit cattle nine clearly could judge

dairy cattle by the score card and select the better milkers, eight were mediocre judges, and two were worse than mediocre, giving the low producing cows better scores than the high producers. On the correlation scale the range of ability was large, from 0.614 to −0.098. The average ability of this group of judges to score cattle for milk yield was 0.246. This is about 25 per cent better than is the judgment of the average trained dairy man as given for all cattle.

If these results are compared with those of tables 1 and 2 several interesting points appear. There is no relation between the average score given by each judge to his group of cows and the ability of that judge to score those cows for milk production. When it is noted that the mental scale of each judge differs considerably this fact is significant. It shows clearly why two equally good judges of cattle may place their cows several points apart, while at the same time they keep the cows in the relative order of milk yield.

The comparison of the mean milk yields of the different groups of cows as given in table 1 with the ability of the judges to score cattle as given in table 3 shows that the cows whose average milk yields are the larger are more easily judged for milk yield than are the groups of cows whose average milk yields are lower. Likewise, it is shown in tables 2 and 3 that the groups composed of cows with quite variable milk yields are more easily judged than are those groups of cows which have milk yields closely similar. It is furthermore shown that the men who can score cattle most accurately for milk yield tend to have their scores show more variation than do the men who cannot score cattle as well. There may be some effect of the kind of judges which score the two groups, the judge scoring the better group being more able than the judge scoring the lower yielding cows.

While other considerations enter into the judging of dairy cattle, its prime object is the selecting of the cows which will be good milk producers. As pointed out for table 3, only about one man in two can even approach doing this. Such being the the case, the individual man will do well before he relies entirely on his ability to select cattle by their conformation to make a

sufficient test to convince himself that he is one of those gifted men who can judge dairy cattle.

The average value of the ability of these nineteen judges to score cattle is only 0.246, measured in the correlation scales. While this indicates the points of conformation as worth something as a means of predicting milk yield, still it does not make them worth a great deal. If comparison is made between this figure and that for the relation of a milk yield of short duration (seven days) with the milk yield of the year period it is found that the milk yield is nearly two times as valuable as an indicator of milk production over the long period as is the conformation of the cow even though this conformation be judged by men of long experience. The further advantage of the short time test lies in the fact that almost anyone can weigh milk. No personal equation need be present in recording the weights. Such being the case, when accurate records are obtainable the dairymen or buyer would do well to consider the milk yields carefully in selecting dairy cows.

Appendix Tables

Correlation tables of milk yield and total score for each judge; Jersey registry of merit cows*

Jersey scorer 1

MILK (365 DAY YIELD)	TOTAL SCORE										
	100-98	98-96	96-94	94-92	92-90	90-88	88-86	86-84	84-82	82-80	
149-139			1								1
139-129											
129-119	1				1						2
119-109				1	1						2
109-99		1	2	1	2	1					7
99-89		1	5	2		2		1			11
89-79		2	6	6	2		2	1			19
79-69			7	9	8	8	1	2			35
69-59		2	7	5	4	7	2			3	30
59-49	1	1	3	2	2	1	2				12
49-39		2			1		1		1		5
39-29											
	2	9	31	26	21	19	8	4	1	3	124

* 365 day milk yield given in thousands.

Scorer 2

MILK (365 DAY YIELD)	TOTAL SCORE															
	100–98	98–96	96–94	94–92	92–90	90–88	88–86	86–84	84–82	82–80	80–78	78–76	76–74	74–72	72–70	
139–129					1											1
129–119																
119–109	1		3	1	1											6
109–99		3	2	1	1											7
99–89	4	2	6	5	4	1	6	1		2						31
89–79	2	7	5	3	2	1	1	3	1	1						26
79–69	1	7	3	5	9	2	7	1		2						37
69–59		1	5	3	4	4	2	8		2		1				30
59–49			3	2	1			3								9
49–39		1														1
39–29																
	8	21	27	20	23	8	16	16	1	7		1				148

Jersey scorer 6

MILK (365 DAY YIELD)	TOTAL SCORE										
	100–98	98–96	96–94	94–92	92–90	90–88	88–86	86–84	84–82	82–80	
109–99				1	1						2
99–89				1	1						2
89–79			3								3
79–69			1	2	2	4	1				10
69–59			1		5	4	1			2	13
59–49			3	2	1	3	2				11
49–39						1					1
39–29											
			8	6	10	12	4			2	42

Scorer 20

MILK (365 DAY YIELD)	TOTAL SCORE									
	100-98	98-96	96-94	94-92	92-90	90-88	88-86	86-84	84-82	
149–139			1							1
139–129										
129–119										
119–109		2	1		1					4
109–99			1	2	1					4
99–89				1						1
89–79		1	4	4			1			10
79–69			3	2		2		1		8
69–59					2	2	2		1	7
59–49					1	1	2			4
49–39										
39–29										
		3	10	9	5	5	5	1	1	39

Jersey scorer 31

MILK (365 DAY YIELD)	TOTAL SCORE								
	100-98	98-96	96-94	94-92	92-90	90-88	88-86	86-84	
169–159				1					1
159–149									
149–139			1						1
139–129									
129–119				1	1				2
119–109			1	2	2				5
109–99			2	2	1	2	1		8
99–89			2	4	7	6	3		22
89–79			2	2	7	4	3		18
79–69		1	6	7	8	8		3	33
69–59			2	13	8	9	4		36
59–49			1	5	6	4	2		18
49–39				1	2				3
39–29									
		1	17	38	42	33	13	3	147

Scorer 33

MILK (365 DAY YIELD)	TOTAL SCORE									
	100-98	98-96	96-94	94-92	92-90	90-88	88-86	86-84	84-82	
149-139			1	1						2
139-129										
129-119			2	2						4
119-109		1	1		1					3
109-99		4	4	1	1	1				11
99-89		3	3	5	3	3	1			18
89-79		1	5	13	8	1	2			30
79-69		2	6	5	8	5	1		1	28
69-59		2	3	9	7	7	2	1	1	32
59-49			1	2	1	3	2	1		10
49-39					1			1	1	3
39-29								1		1
		13	26	38	30	20	8	4	3	142

Jersey scorer 37

MILK (365 DAY YIELD	TOTAL SCORE									
	100-98	98-96	96-94	94-92	92-90	90-88	88-86	86-84	84-82	82-80	
149-139							1				1
139-129											
129-119		1									1
119-109				3		1					4
109-99			1	1	1				1		4
99-89		1		1	1	1	2				6
89-79					2	4		1			7
79-69			1	1	7	1	1	2			13
69-59					2	2	1	2	1	1	9
59-49					1	1	2			2	6
49-39											
39-29											
		2	2	6	14	10	7	5	2	3	51

Jersey scorer 47

MILK (365 DAY YIELD)	TOTAL SCORE											
	100–98	98–96	96–94	94–92	92–90	90–88	88–86	86–84	84–82	82–80	80–78	
139–129						1						1
129–119			1				1					2
119–109										1		1
109–99				1	2	1						4
99–89			2		2						1	5
89–79			3	1	1	2	1			1		9
79–69		2	1	2	1	2	1	1				10
69–59		1		3	1	7	3	1		1		17
59–49		1	1	4	3	4			1			14
49–39				2	1							3
39–29												
		4	8	13	11	17	6	2	1	3	1	66

Jersey scorer 51

MILK (365 DAY YIELD)	TOTAL SCORE								
	100–98	98–96	96–94	94–92	92–90	90–88	88–86	86–84	
109–99				1	1				2
99–89					1				1
89–79			2	2	3				7
79–69				1		4		1	6
69–59				1	3	2			6
59–49					1	1			2
49–39				1					1
39–29									
			2	6	9	7		1	25

Scorer 52

MILK (365 DAY YIELD)	TOTAL SCORE										
	100–98	98–96	96–94	94–92	92–90	90–88	88–86	86–84	84–82	82–80	
109–99			1								1
99–89				1			1				2
89–79				1	2		1				4
79–69				2		3		1		1	7
69–59						3	1		1		5
59–49				1		2	2				5
49–39				1		1					2
39–29											
			1	6	2	9	5	1	1	1	26

Jersey scorer 58

MILK (365 DAY YIELD)	TOTAL SCORE											
	100–98	98–96	96–94	94–92	92–90	90–88	88–86	86–84	84–82	82–80	80–78	
109–99						1					1	2
99–89					1			2		2		5
89–79					1						1	2
79–69						2	2			1		5
69–59					1	2	4				1	8
59–49							1		1	1		3
49–39									1			1
39–29												
					3	5	7	2	2	4	3	26

Jersey scorer 59

MILK (365 DAY YIELD)	TOTAL SCORE										
	100–98	98–96	96–94	94–92	92–90	90–88	88–86	86–84	84–82	82–80	
129–119				1	1						2
119–109				2	1						3
109–99						1					1
99–89				1		4	2				7
89–79					3	2	2	3			10
79–69				2	4	5	2			1	14
69–59				4	3	4			1		12
59–49						1		1			2
49–39											
39–29											
				10	12	17	6	4	1	1	51

Jersey scorer 76

MILK (365 DAY YIELD)	TOTAL SCORE												
	100–98	98–96	96–94	94–92	92–90	90–88	88–86	86–84	84–82	82–80	80–78	78–76	
129–119			1										1
119–109													
109–99		1	2	1									4
99–89						2	1		1				4
89–79		1	1	2	3	2							9
79–69			1	1	2		2					1	7
69–59					1	1							2
59–49					1		3						4
49–39							1						1
39–29													
		2	5	4	7	5	7		1			1	32

Scorer 80

MILK (365 DAY YIELD)	TOTAL SCORE									
	100–98	98–96	96–94	94–92	92–90	90–88	88–86	86–84	84–82	
139–129				1						1
129–119										
119–109										
109–99										
99–89				1						1
89–79		1	2	1	1				1	6
79–69			1	1		2				4
69–59				4	3	1	1			9
59–49				1	3					4
49–39										
39–29										
		1	3	9	7	3	1		1	25

Jersey scorer 84

MILK (365 DAY YIELD)	TOTAL SCORE															
	100–98	98–96	96–94	94–92	92–90	90–88	88–86	86–84	84–82	82–80	80–78	78–76	76–74	74–72	72–70	
119–109		1				1										1
109–99																1
99–89			2	1	1	1		1		1						7
89–79		1				4	1	1								7
79–69					2		1	1	2	2	2	1				11
69–59					1			1	4	3					1	10
59–49									1							1
49–39										1						1
39–29																
		2	2	1	4	6	2	4	7	7	2	1			1	39

Scorer 89

MILK (365 DAY YIELD)	TOTAL SCORE								
	100–98	98–96	96–94	94–92	92–90	90–88	88–86	86–84	
119–109				1					1
109–99			1		1				2
99–89			2	3	3				8
89–79		1	1	2		1			5
79–69			1			2		1	4
69–59				1	1	1	1		4
59–49					2				2
49–39									
39–29									
		1	5	7	7	4	1	1	26

Jersey scorer 103

MILK (365 DAY YIELD)	TOTAL SCORE									
	100–98	98–96	96–94	94–92	92–90	90–88	88–86	86–84	84–82	
149–139			1							1
139–129										
129–119										
119–109					2					2
109–99										
99–89		1	1	3						5
89–79				1	3	1				5
79–69			2	5	2	3	2	2		16
69–59				3	3	1	2	1	1	11
59–49			1	2	5	1	4	4		17
49–39				1	1					2
39–29										
		1	5	15	16	6	8	7	1	59

Scorer 117

MILK (365 DAY YIELD)	TOTAL SCORE									
	100–98	98–96	96–94	94–92	92–90	90–88	88–86	86–84	84–82	82–80	
109–99				1					1		2
99–89					1		1				2
89–79			1	1		1		3			6
79–69					1	2	1	3	5	1	13
69–59			1	2	3		2	2	1	2	13
59–49				1		2	1	1	1		6
49–39											
39–29											
			2	5	5	5	5	9	8	3	42

Jersey scorer 118

MILK (365 DAY YIELD)	TOTAL SCORE									
	100–98	98–96	96–94	94–92	92–90	90–88	88–86	86–84	84–82	
109–99			1							1
99–89					1	1				2
89–79			2	2	1	1	1			7
79–69			6	6	1	2	1	2		18
69–59			1	5	5	1		1	1	14
59–49			2	3	4	5				14
49–39										
39–29										
			12	16	12	10	2	3	1	56

THE PROTEINS OF COTTONSEED MEAL[1]

I. AMINO ACID CONTENT

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I. INTRODUCTION

One of the earliest references to the proteins of cottonseed meal was made by Ritthausen (1), who separated the proteins in the form of spheroids. Osborne and Voorhees (2) isolated a protein from cottonseed meal which had the nature of a globulin, being soluble in salt solutions, and comprised 42.3 per cent of the total nitrogen of the meal. Another protein (or proteins) was found to be insoluble in salt solutions but soluble in 0.2 per cent potash solution and amounted to 44.3 per cent of the total nitrogen of the meal. Two per cent of the total nitrogen was present in the form of water soluble proteose.

TABLE 1

Percentage of nitrogen in the different groups in various proteins

SOURCE	N AS AMMONIA	BASIC N	NON-BASIC N	N IN MgO PRECIPITATION	TOTAL N
Globulin, cottonseed	1.92	5.71	11.01		18.64
Globulin, wheat	1.42	6.83	9.82	0.28	18.39
Zein, maize	2.97	0.49	12.51	0.16	16.13
Hordein, barley	4.01	0.77	12.04	0.23	17.21

The distribution of nitrogen in various protein bodies was studied exhaustively by Osborne and Harris (3), who employed the modified Hausmann method (4). The following values are typical of their results.

[1] The results presented in this paper formed part of a thesis submitted to the Graduate School of the University of Illinois in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Animal Husbandry.

These investigators state that "This wide variation in the proportion of basic decomposition products of the various proteins . . . . raises important questions regarding their food value." Osborne (5) further found that the basic nitrogen of the globulin of cottonseed, as determined by precipitation with phosphotungstic acid, consisted of 3.46 per cent histidine, 13.51 per cent arginine and 2.06 per cent lysine.

The content of the mono-amino acids of the "edestin" of cottonseed meal was determined by Abderhalden and Rostoski (6) by the use of the Fischer ester method (7), and is as follows, calculated for dry, ash free edestin of cottonseed:

	per cent
Glycocoll	1.2
Alanin	4.5
Amino valerianic acid	Present
a-proline	2.3
Leucin	15.5
Glutamic acid	17.2
Aspartic acid	2.9
Phenyl alanin	3.9
Serin	0.4
Tyrosin	2.3
Tryptophane	Present

The quantitative determination of the amino acids of feedingstuffs by means of the Van Slyke method (8) was undertaken by Grindley and his co-workers (9), and a little later by Nollau (10). In Nollau's procedure, samples of the finely ground feeds were hydrolyzed with 20 per cent hydrochloric acid until the content of amino acid, as determined by the Van Slyke method, became constant. The material insoluble in hydrochloric acid was filtered off, the clear extract concentrated under diminished pressure and made up to a certain volume. The total nitrogen content of this extract was used as a basis for calculating the final results. In a report of the subsequent work of Grindley and co-workers (11), it is claimed that since Nollau filtered off the solid residue after hydrolysis of the feedingstuff and before making his total nitrogen determinations upon which the final calculations were based, that his results are not accurate since a part of the total nitrogen was undoubtedly discarded in the solid residue.

The heats of combustion of several vegetable proteins were carefully determined by Benedict and Osborne (12). The globulin of cottonseed was found to yield 5596 calories per gram, compared to 5358 calories per gram for the globulin of wheat and 5916 calories per gram in the case of the hordein of barley. In commenting upon their determinations, the investigators state that "many irregularities. . . . appear, which are doubtless due to the different proportion of the various amino acids which constitute the molecules of the different proteins."

It is evident from the foregoing discussion that our knowledge of the composition of the proteins of cottonseed meal is very incomplete. The globulin is the only protein of cottonseed which has been isolated in pure form and whose composition has been determined. The globulin, however, according to Osborne and Voorhees, contains only 42.3 per cent of the total nitrogen of the cottonseed. The character, identity and chemical composition of the remaining proteins are practically unknown, and it is evident from the data given above that our knowledge of the distribution of the nitrogen in the proteins of cottonseed meal is very meager indeed. The investigation of the distribution of the nitrogen in the proteins of cottonseed meal therefore constituted the object of this study.

II. METHODS EMPLOYED IN CHEMICAL ANALYSIS[2]

The method of analysis employed consisted of two main procedures. The first consisted of a series of extractions whereby the nonprotein together with a very small amount of protein was first removed, and following this, the proteins were extracted from the residual matter of the sample which consisted mostly of fiber. The second main procedure embraced the hydrolysis of the extracted proteins, and the analysis of the resulting solution

[2] The method of procedure here outlined is one which has been developed and perfected in this laboratory by Dr. H. S. Grindley, Mr. T. S. Hamilton and associates (9, 11, 33, 36 and unpublished manuscripts). The method of extraction preliminary to hydrolysis of the proteins has been developed entirely in this laboratory, while the actual determination of the nitrogen in the different groups follows closely the method of Van Slyke, but includes modifications perfected in this laboratory.

for certain amino acid and other groups according to the general method of Van Slyke (8).

The sample of cottonseed meal was prepared from good quality commercial meal, finely ground and passed through a 40-mesh sieve. Each sample taken for analysis weighed 15 grams and contained 1.0194 grams of nitrogen, or about 6 grams of protein.

In the first three extractions, which were carried out consecutively, cold anhydrous ether, cold absolute alcohol and cold 1.0 per cent trichloracetic acid were used. The samples of feeding stuff were placed in 500 cc. centrifuge bottles and 100 to 200 cc. of the reagents added. The bottles were placed on a shaking machine which rolled them back and forth continually. Usually two extractions were made each twenty-four hours, one extraction period being seven to eight hours and the other 15 to 16 hours in length. At the end of the extraction period, the sides of the bottles were washed down with the reagent, the bottles centrifuged and the clear supernatant liquid decanted. Usually six or seven extractions with each reagent were necessary.

The ether and alcohol extracts were filtered and any residues returned to the centrifuge bottles. After slight acidification with sulphuric acid, the ether and alcohol were evaporated and recovered and total nitrogen determinations made on the residue. The small amount of protein removed in the trichloracetic acid extracts was recovered by precipitation with colloidal ferric hydroxide (containing 5 per cent Fe_2O_3) in boiling solution. The precipitate was transferred to a digestion flask with 20 per cent hydrochloric acid, and total nitrogen determined in the filtrate.

The bulk of the proteins was removed from the residue remaining after extraction with 1.0 per cent trichloracetic acid by extraction, first, with dilute sodium hydroxide solution, then with 20 per cent hydrochloric acid followed by treatment with 5 per cent sodium hydroxide solution. The dilute sodium hydroxide solution used during the shorter period was a 0.2 per cent solution and that during the longer period a 0.1 per cent solution. These extracts were neutralized, acidified with hydro-

chloric acid and concentrated in vacuo to a small volume. An equal volume of concentrated hydrochloric acid was then added. The residues remaining after treatment with dilute sodium hydroxide solution were boiled for three minutes with 20 per cent hydrochloric acid. After cooling, the solution was filtered off, the residue washed and the procedure repeated once. The washings were evaporated to a small volume, an equal volume of concentrated hydrochloric acid added and the washings then combined with the main hydrochloric acid extract. The residues insoluble in hydrochloric acid were treated three times with 5 per cent sodium hydroxide solution using centrifuge bottles as in former extractions. After washing the residues nearly free from alkali, they were submitted to Kjeldahl analysis. The extracts and washings were acidified with hydrochloric acid, concentrated in vacuo and transferred to digestion flasks with an equal volume of concentrated hydrochloric acid.

The proteins precipitated by colloidal iron and the proteins removed by extraction with dilute sodium hydroxide, 20 per cent hydrochloric acid and 5 per cent sodium hydroxide were completely hydrolyzed by boiling for fifteen hours upon a combined electric plate and sand bath under reflux condensers. The resulting solutions were combined and analysis for the chemical groups characteristic of certain amino acids executed essentially as directed by Van Slyke (8), but with the use of minor improvements perfected in this laboratory.

III. DISCUSSION OF RESULTS

The results obtained by application of the method of chemical analysis outlined in the preceding section to eight portions of the same original sample of cottonseed meal are shown in the accompanying tables 2 and 3. Table 2 shows the values expressed in percentage of the total nitrogen present in the sample of feeding stuff when it was taken for analysis, while table 3 shows the same values expressed in percentage of the feeding stuff itself.

Two averages are included in the tables. The first is compiled by taking the average of all values obtained by analysis of the entire eight samples. The second average is obtained by

TABLE 2

Summary of the results of analysis of the proteins of cottonseed meal

(Results expressed in percentage of the total nitrogen in sample)

SAMPLE NUMBER	NONPROTEIN NITROGEN				RESULTS OF THE VAN SLYKE ANALYSIS										UNCHARACTERIZED NITROGEN LOST IN METHOD OF ANALYSIS						TOTAL
	Soluble in absolute ether	Soluble in absolute alcohol	In filtrate from colloidal iron	Total nonprotein nitrogen	Insoluble humin nitrogen	Soluble humin nitrogen	Ammonia nitrogen	Arginine nitrogen	Cystine nitrogen	Histidine nitrogen	Lysine nitrogen	Amino nitrogen in filtrate from the bases	Non-amino N in filtrate from the bases	Nonprotein N + results of Van Slyke analysis	Insoluble in strong alkali	Unadsorbed humin (filtered from solution during decomposition of phosphotungstate precipitate)	Soluble in amyl alcohol-ether mixture	In residue from solution of the bases	In residue from solution of the filtrate from the bases	Total nitrogen lost	Total nitrogen accounted for
C1	0.021	0.570	4.943[2]	5.534	2.609	3.462	9.455	18.569	0.961	6.095	3.871	38.495	4.079	93.130	0.220	2.403	0.906	0.206	0.017	3.752	96.992
								18.775	0.961	4.876	4.609	41.466	2.463	94.210		2.145	1.043	0.206	0.055	3.669	97.879
C2	0.089	0.618	4.870[2]	5.577	2.609	5.117	9.689	18.981	0.821	5.622	3.625	39.646	3.908	95.595	0.260	2.042	0.734	0.103	0.027	3.166	98.761
								19.119	0.983	7.038	2.494	41.432	2.955	97.013		1.081	1.078	0.326	0.051	2.796	99.809
C3	0.202	0.652	5.053[2]	5.907	2.492	5.459	9.929	18.295	1.035	7.966	3.471	39.157	2.348	96.062	0.302	1.867	0.614	0.240	0.079	3.102	99.164
								18.638	1.101	7.120	3.668	38.546	1.454	94.314		1.448	0.961	0.200	0.133	3.044	97.358
C4	0.109	0.614	5.531[1]	6.254	2.623	4.477	8.892	19.160	1.285	6.441	4.430	39.828[a]	0.161	93.551	0.233	3.011	0.841	0.243	0.130[a]	4.458	98.009
								17.635	0.961	8.038	4.510	39.828	0.161	93.379	—[b]	3.076	1.428	0.247	0.130	5.114	98.493
C5	0.081	0.506	5.245[1]	5.832	2.981	2.415	9.249	18.701	1.051	6.987	5.042	41.659	2.784	96.701		1.230	0.645	0.255	0.217	2.777	99.478
								16.339	1.051	10.181	3.881	42.257	2.577	96.763		1.153	0.736	0.601	0.082	3.002	99.765

C6	0.129	0.489	5.722[1]	6.340	2.930	2.650	9.318	19.580	0.963	6.568	4.780	41.659	2.504	97.292	0.685	1.021	0.642	0.445	0.096	2.889	100.818
								19.305	0.933	6.163	5.216	42.141	2.076	97.072		1.016	0.917	0.315	0.096	3.029	100.101
C7	0.081	0.420	6.097[1]	6.598	2.763	2.334	9.002	17.932	0.692	9.627	3.503	39.131	2.921	94.503	0.719	0.818	0.994	0.068	0.054	2.653	97.156
								18.041	0.722	9.074	3.697	39.276	3.253	94.760		0.725	1.057	0.124	0.076	2.701	97.461
C8	0.047	0.506	7.012[1]	7.564	2.772	2.746	9.764	19.799	0.810	5.657	5.845	43.023	3.095	101.076	0.589	1.384	1.049	0.151	0.054	3.227	104.303
								20.404	0.751	7.271	4.702	43.939	3.812	103.726		1.343	1.087	0.115	0.082	3.216	106.942
Average[3]	0.095	0.547	5.559[1]	6.201	2.772	3.582	9.412	18.705	0.943	7.170	4.209	40.718	2.535	96.197	0.430	1.610	0.921	0.240	0.086	3.287	99.484
Average[4]	0.125	0.545	5.436[1]	6.106	2.699	3.890	9.485	18.736	0.906	7.397	3.807	40.124	2.677	95.827	0.492	1.252	0.875	0.228	0.076	2.923	98.750

[a] Determination lost. Value from other half of sample substituted.
[b] Determination lost. Average of 7 determinations used.
[1] After first precipitation.
[2] After second precipitation.
[3] Average of all determinations.
[4] Average of complete samples C2, C3, C6, C7.

TABLE 3

Summary of the results of analysis of the proteins of cottonseed meal

(Results expressed in percentage of the feeding stuff)

SAMPLE NUMBER	NONPROTEIN NITROGEN				RESULTS OF THE VAN SLYKE ANALYSIS									UNCHARACTERIZED NITROGEN LOST IN METHOD OF ANALYSIS					TOTAL	
	Soluble in ether	Soluble in absolute alcohol	In filtrate from colloidal iron	Total nonprotein nitrogen	Insoluble humin nitrogen	Soluble humin nitrogen	Ammonia nitrogen	Arginine nitrogen	Cystine nitrogen	Histidine nitrogen	Lysine nitrogen	Amino nitrogen in filtrate from bases	Non-amino nitrogen in filtrate from bases	Insoluble in strong alkali	Undecorbed humin (filtered from solution during decomposition of phosphotungstate precipitate)	Soluble amyl alcohol-ether	Residue from solution of bases	Residue from solution of filtrate of bases	Nonprotein N + results of Van Slyke analysis	Total nitrogen accounted for
C1	0.0014	0.0387	0.3360[a]	0.3761	0.1769	0.2352	0.6426	1.2620	0.0653	0.4142	0.2631	2.6157	0.2773	0.0150	0.1633	0.0616	0.0140	0.0012	6.3284	6.5835
								1.2760	0.0653	0.3314	0.3133	2.8180	0.1674		0.1458	0.0709	0.0140	0.0037	6.4022	6.6516
C2	0.0061	0.0420	0.3310[a]	0.3790	0.1773	0.3478	0.6585	1.2900	0.0558	0.3821	0.2464	2.6940	0.2656	0.0177	0.1388	0.0499	0.0070	0.0019	6.4966	6.7119
								1.2993	0.0668	0.4783	0.1695	2.8153	0.2009		0.0735	0.0733	0.0222	0.0035	6.5928	6.7830
C3	0.0137	0.0443	0.3435[a]	0.4015	0.1694	0.3710	0.6748	1.2433	0.0703	0.5414	0.2360	2.6610	0.1596	0.0205	0.1269	0.0418	0.0163	0.0054	6.5283	6.7392
								1.2666	0.0748	0.4839	0.2493	2.6193	0.0988		0.0985	0.0653	0.0136	0.0091	6.4094	6.6164
C4	0.0075	0.0417	0.3759[a]	0.4250	0.1783	0.3043	0.6043	1.3021	0.0873	0.4377	0.3011	2.7067[a]	0.0110	0.0158	0.2046	0.0572	0.0165	0.0089[a]	6.3579	6.6609
								1.1985	0.0653	0.5462	0.3065	2.7067	0.0110		0.2091	0.0971	0.0168	0.0089	6.3462	6.6039
C5	0.0055	0.0345	0.3563[a]	0.3963	0.2026	0.1641	0.6286	1.2709	0.0715	0.4749	0.3427	2.8310	0.1892	—[b]	0.0836	0.0439	0.0173	0.0147	6.5718	6.7605
								1.1104	0.0715	0.6919	0.2638	2.8715	0.1751		0.0784	0.0500	0.0409	0.0056	6.5758	6.7799

C6	0.0088	0.0332	0.3889[1]	0.4309	0.1991	0.1801	0.6333	1.3306	0.0655	0.4464	0.3249	2.8310	0.1702	0.0465	0.0694	0.0437	0.0302	0.0065	6.6120	6.8083
								1.3120	0.0635	0.4188	0.3545	2.8630	0.1411		0.0691	0.0623	0.0215	0.0065	6.5963	6.8022
C7	0.0055	0.0285	0.4144[1]	0.4484	0.1878	0.1586	0.6118	1.2186	0.0471	0.6543	0.2381	2.6590	0.1986	0.0489	0.0556	0.0675	0.0047	0.0037	6.4223	6.6028
								1.2260	0.0491	0.6167	0.2513	2.6690	0.2211		0.0493	0.0719	0.0084	0.0052	6.4398	6.6235
C8	0.0032	0.0344	0.4765[1]	0.5140	0.1884	0.1866	0.6635	1.3456	0.0551	0.3845	0.3972	2.9235	0.2104	0.0400	0.0941	0.0713	0.0103	0.0037	6.8689	7.0883
								1.3866	0.0511	0.4942	0.3196	2.9860	0.2591		0.0913	0.0739	0.0078	0.0056	7.0492	7.2678
Av[3]	0.0065	0.0372	0.3778	0.4214	0.1849	0.2434	0.6396	1.2712	0.0641	0.4873	0.2861	2.7669	0.1723	0.0292	0.1095	0.0626	0.0163	0.0059	6.5374	6.7609
Av[4]	0.0085	0.0370	0.3695	0.4150	0.1834	0.2644	0.6446	1.2733	0.0616	0.5027	0.2588	2.7265	0.1820	0.0334	0.0851	0.0595	0.0155	0.0052	6.5123	6.7110

[1] After first precipitation.
[2] After second precipitation.
[3] Average of all determinations.
[4] Average of complete samples C2, C3, C6, C7.
[5] Determination lost. Value for other half of sample substituted.
[6] Determination lost. Average of seven determinations used.

averaging the results secured in the analysis of the complete samples C2, C3, C6 and C7. It is believed that the latter average more nearly expresses the actual composition of the commercial cottonseed meal used, for the following reasons: (a) These samples, i.e., C2, C3, C6 and C7 show the best agreeing results throughout. The two parts of sample C1 agree well in the amount of arginine nitrogen, but show a considerable difference in the amounts of amino nitrogen, non-amino nitrogen and histidine nitrogen. The totals of the nonprotein nitrogen plus the protein nitrogen are considerably below the average of all the samples. In sample C4 the non-amino nitrogen is particularly low, this value being one of the principal factors contributing to the noticeably low nonprotein plus protein of this sample. Sample C5 is omitted from the average partly on account of the non-agreement of its arginine nitrogen and histidine nitrogen values. Of the latter values, one is 3 per cent above the average of all samples. (b) The second average, i.e., of samples C2, C3, C6 and C7, includes values which are most free from obvious errors. In making the determinations in the case of sample C4, two determinations were lost, and in the case of sample C5, one determination was lost. While the results obtained for sample C8 agree fairly well throughout with themselves and with the average, the results are consistently high, and it is excluded from this average on the grounds of the totals obtained, which are obviously too high.

Nonprotein nitrogen. The first section of tables 2 and 3 shows the amount of nitrogen removed in the preliminary extractions with absolute ether, absolute alcohol and trichloracetic acid. While the absolute ether in the cold is used primarily to remove the lipins, such as the oils, waxes, etc., it also dissolves various amounts of other substances, such as coloring matters, and at the same time a small amount of nitrogen. The thorough extraction with absolute alcohol following the treatment with absolute ether presumably completes the extraction initiated by ether. The alcohol removes somewhat more nitrogen than the extraction with ether. The bulk of the nonprotein nitrogen accounted for, about 89 per cent of the total, remains, however, in the tri-

chloracetic acid extracts after precipitation of the proteins by colloidal ferric hydrate and the removal of the precipitate by filtration. That the nitrogen determined in these latter extracts is not protein nitrogen is apparent from the work of Van Slyke, Vinograd, Vilchur and Losee (13), Hill (14), Wolff (15), and others.

It seems from the study of the character of the nonprotein nitrogenous constituents of feedingstuffs by Grindley and Eckstein (16) that the forms of nitrogen represented in this classification consist principally of those forms naturally resulting from the cleavage of the proteins upon hydrolysis and therefore could not interfere in the determination of the characteristic chemical groups of the proteins were they not removed in the preliminary extractions. Neidig and Snyder (17), who recently determined the proportion of nitrogen in the form of ammonia in the ether extracts and alcohol extracts of different kinds of silage, found that from 28.1 per cent to 100 per cent of the ether extract nitrogen consists of ammonia nitrogen, while from 14.2 per cent to 23.4 per cent of the alcohol extract nitrogen is yielded as ammonia nitrogen. This indicates that only a part of the nitrogen soluble in ether and alcohol would appear in the ammonia fraction were it not removed previous to hydrolysis. Therefore, the removal of the nonprotein nitrogen at this point avoids possible complications in the further prosecution of the analytical procedure, and it is believed that the accuracy of the further determinations has been increased over that of previous methods by the removal of the nonprotein nitrogen before hydrolysis of the proteins. The total amount of the nonprotein nitrogen present in cottonseed meal found by the method used amounted to 6.106 per cent of the total nitrogen contained in the feedingstuff.

Results of the Van Slyke analysis. It is a matter of common knowledge that one of the important sources of loss in the analysis of proteins by methods involving the employment of acid hydrolysis is the formation of an insoluble black substance called humin. The term melanin is also applied to this substance, on account of its supposed relationship or similarity to the

naturally occurring body pigments. The amount of humin formed in acid hydrolysis of the proteins is greatly increased by the presence of carbohydrates, as shown by Gortner and associates (18, 19), Hart and Sure (20), and Osborne, Van Slyke, Leavenworth and Vinograd (21). A part of the humin formed, however, remains in solution in the hydrochloric acid, and is termed soluble humin.

In these experiments the soluble humin which is adsorbed by the lime used in neutralizing the hydrolysate when determining ammonia nitrogen, carried with it a larger amount of nitrogen than the insoluble humin. The sum of the insoluble plus the soluble humin nitrogen found amounts to 6.589 per cent, which constitutes no inconsiderable error, since at present it is impossible to determine the character of the nitrogen discarded in this form.

It may be noted by referring to table 1 that the amount of soluble humin nitrogen in the first four samples is considerably greater than in the succeeding four. Possibly this is due to a slight variation in the analytical procedure. In the case of samples C1 to C4, inclusive, it was necessary to add 75 to 90 cc. of calcium hydroxide in order to neutralize the hydrochloric acid before distillation of ammonia. About 20 cc. in excess were then added. With the next four samples evaporation of the acid hydrolysate in vacuo was continued longer in order to drive off a greater proportion of the hydrochloric acid. In consequence, only 30 to 40 cc. of calcium hydroxide were necessary to effect neutralization, and in these cases only a small excess, about 10 cc., of calcium hydroxide was added. The hypothesis is put forward that the presence of a large excess of calcium hydroxide during the distillation of ammonia may result in the adsorption of some amino acid nitrogen which is incompletely removed in the subsequent washing of the sticky mass.

When it is recalled that the proteins of cottonseed meal form approximately 43 per cent of the feedingstuff, the amount of nitrogen in the humin resulting from the hydrolysis of these proteins, as determined in these experiments, is not excessive when compared to the amounts obtained in the hydrolysis of

pure proteins by Van Slyke (8), some of whose results are shown in the accompanying table.

The amount of nitrogen recovered as ammonia was quite constant in all the samples. Little can be said in regard to the significance of this fraction, aside from the fact that the proportion of the total nitrogen of cottonseed meal which appears as ammonia is quite in harmony with that of other feedingstuffs.

A particularly characteristic feature of the amino acid content of cottonseed meal is the remarkably high content of arginine. This is much higher than that found in any other feeding stuff so far examined, with the exception of peanuts, although it is not so high as that found in some other vegetable proteins. Van Slyke (8) found 27.05 per cent arginine nitrogen in edestin

TABLE 4

Amounts of humin nitrogen in pure proteins expressed in percentage of the total nitrogen of the protein

PROTEIN AND DESCRIPTION	HUMIN NITROGEN
	per cent
Gliadin from wheat	0.86
Edestin	1.83
Fibrin (Merck's)	3.43
Oxyhemoglobin ("pure, crystalized")	3.60
Dog's hair	7.35

while Nollau reported that hemp seed, peanuts, black walnuts, and hickory nuts have an arginine nitrogen content of more than 20 per cent.

In the Van Slyke procedure the only amino acids determined by direct analysis are arginine and cystine. Just how much importance may be attached to the results obtained for the latter is questionable, even though the values found in the different samples do not vary widely. These values, however, probably fall short of the true value, due to losses in the determination of cystine. Van Slyke (8) has shown that boiling cystine for sixteen hours with hydrochloric acid resulted in the conversion of one-half of its nitrogen into forms not precipitable by phosphotungstic acid. Since in the analytical procedure described above, hydrolysis of the proteins was carried out by

boiling them with 20 per cent hydrochloric acid for fifteen hours, it is probable that much of the cystine was destroyed during that reaction. If it is assumed that the correct value for cystine should be double that actually obtained, then the total nitrogen of the bases would amount to 31.75 per cent of the total nitrogen of the feedingstuff.

The values given for histidine and lysine are somewhat variable among the different samples. These variations are likely due in large measure to the indirect method used in their determination, since slight errors in any or all of the three direct determinations of arginine nitrogen, cystine nitrogen and the total nitrogen of the bases are doubtless all reflected at these points.

The content of mono-amino acid nitrogen of cottonseed meal is considerably less than that found in other feedingstuffs, possibly due to the greater proportion of the total nitrogen which is formed by the basic amino acids. One of the interesting features of the results of the Van Slyke analysis of the proteins of cottonseed meal is brought out in the summation of the ammonia nitrogen, the nitrogen of the bases, mono-amino acid nitrogen, and non-amino acid nitrogen, the four groups which represent the total content of strictly amino acid nitrogen as determined by this method. The sum of these is 83.132 per cent. While this sum is not so great as that in the case of some other feedingstuffs or of animal proteins, as determined by previous investigators employing the Van Slyke method of analysis, it is a much larger amount than it was possible to secure in most cases from comparable sources by the methods of isolation and purification employed by the earlier investigators. Thus the tabulations of Lusk (22), combining the results of Osborne and associates in this field, show the maximum amino acid content of zein of maize, to be 88.87 per cent and that of gliadin of wheat as 85.68 per cent, but in the majority of cases the sum of the nitrogen content of the amino acids actually isolated from vegetable proteins ranges from 50 to 65 per cent of the total nitrogen of the protein.

Uncharacterized nitrogen lost in analysis. In the various steps of the analytical procedure small amounts of nitrogen of unknown character are included in residues and solutions which are discarded. In general, these have been disregarded by workers in other laboratories, especially those losses occurring at points indicated in table 2 by the last four of the subheadings included under the heading "Uncharacterized nitrogen lost in analysis," but in this laboratory the nitrogen discarded at each of these steps has been determined. Under the above mentioned headings, it is shown that, on the average, only 0.492 per cent of the total nitrogen remains in the residues insoluble in strong alkali, or in other words 99.508 per cent of the total nitrogen of the feedingstuff is extracted as a result of the method employed, and that in individual cases as much as 99.78 per cent of the total nitrogen present was removed. As previous workers failed to isolate the proteins from the feedingstuff before hydrolysis, it is not established that part of the insoluble residue discarded in their methods did not include some nitrogen in the form of non-hydrolyzed protein although this does not seem highly probable. It is believed, however, that the nearly complete extraction of the proteins before hydrolysis lends to the accuracy of the method by facilitating hydrolysis and in reducing the amount of humin.

The largest item of loss occurs in the residue which remains after dissolving the precipitate of the bases in the amyl alcohol-ether mixture. This, presumably, is soluble humin which has not been adsorbed by the lime in the determination of ammonia, and fouls the solution at this point. This difficulty was also encountered by Menaul (23), who employed a preliminary precipitation with phosphotungstic acid in boiling solution for the separation of the humin and ammonia before the precipitation of the bases. In the present investigation, very little of the soluble humin appeared when the bases were precipitated, in most cases the precipitates being free from black particles. Washing with alternate portions of amyl alcohol-ether and water and then taking up the residue and washing thoroughly with water seemed to have little effect in reducing this source

of loss. A considerable portion of the nitrogen lost is soluble in the amyl alcohol-ether mixture, while smaller losses occur in the residues resulting from concentration of the solutions of the bases and filtered from the bases. Presumably, the second, third and fourth items of loss include some nitrogen which should be credited to the bases, but the character of this nitrogen was not determined. If these losses can be reduced, the total nitrogen of the bases of cottonseed meal may be found to be somewhat greater than the amount here reported.

Total nitrogen accounted for. Summation of the nitrogen found in the various fractions of the protein molecule together with that in the unavoidable losses in the procedure gives totals which average 98.75 per cent. While the use of the Van Slyke method of analysis has enabled others to account for as great a proportion of the nitrogen of feedingstuffs, it is doubtful, for reasons pointed out below, if their results give as accurate a picture of the distribution of nitrogen in feedingstuffs as is obtained by the procedure employed in the present investigation.

Physiological significance of the basic amino acids. Our knowledge of the physiological rôle of arginine and histidine has been enhanced by the studies of Ackroyd and Hopkins (24). Employing rations in which the nitrogen was provided in the form of hydrolyzed casein from which these two amino acids had been removed by precipitation according to the method of Kossel and Kutcher, it was found that rats receiving these rations declined rapidly in weight, but that when either amino acid was returned to the ration, loss in weight was prevented and some growth ensued. The investigators suggest that possibly either of these amino acids may be converted into the other by the animal body. It was further observed that when arginine and histidine are removed from the ration, the excretion of allantoin, which is the main end product of purine metabolism in the rat, was lowered. Subsequent experiments proved that the falling off of allantoin excretion was not due to lowered metabolism. From these observations and from the fact that the arginine, histidine and guanine molecules have similar structural

relationships, it was concluded that possibly one of the functions of arginine and histidine is to furnish the raw material for the purine metabolism of the animal organism.

The above conclusion regarding the importance of arginine in purine metabolism is given added weight by the findings of Myer and Fine (25) regarding the creatine content of muscle. Differences of as much as 2.5 per cent in the creatine content of muscle were noted as a result of feeding rations high and low in arginine.

That cystine plays an important part in nutrition has been brought out by several investigators, among them Osborne and Mendel (26). The latter obtained adequate growth by the addition of cystine to rations containing 9 per cent of casein, on which growth had been limited. Geiling (27), working in this laboratory, concluded that cystine seems to be necessary for the maintenance of adult mice. The importance of cystine to the animal organism is admirably set forth by Matthews (28).

In the intermediary metabolism of the body, that is, the metabolism of the tissue, sulphur probably plays a very important rôle. This is shown not only by the fact that it is absolutely necessary for the continued existence of the body, as necessary as nitrogen or any of the other elements, but also by the fact that it is one of the most labile elements of the protein molecule. No other element is split off from the proteins with greater ease than this. It is, indeed, the labile element *par excellence*. Moreover, cysteine, which is one of the amino acids, readily oxidizes itself. It is a reducing body. It oxidizes spontaneously and there are many points in its oxidation which strongly resemble the process of respiration. Thus the most favorable concentration of hydrogen ions for the oxidation of cysteine is the same as that in protoplasm; both cysteine and protoplasm are poisoned by many of the same substances, such as the nitriles, the cyanides, acids, and the heavy metals; their oxidations are catalyzed or hastened in the same manner by iron, arsenic and some other agents. For these reasons it has been suggested by Hefter and the author that there is more than a superficial connection between the oxidation of cysteine and the respiration of the cell.

The necessity of lysine for growth has been conclusively demonstrated by Osborne and Mendel (29). When gliadin of wheat, which contains only a minute amount of lysine, formed the sole source of protein in the rations of rats, the live weight of the animals was maintained over long periods, but normal growth could not be secured. When lysine was added to the rations, normal growth occurred. In other investigations (30), in which zein of maize was used as the source of the protein, it was found that a rat could be maintained at an almost constant weight of 50 grams for a period of one hundred and eighty-two days when tryptophane was added to the extent of 3 per cent of the zein. The further addition of lysine induced normal growth. Further study (31) of the necessity of lysine in the ration convinced these investigators that about 2 per cent of the protein of the ration must consist of lysine in order to promote normal growth in the rat. Osborne and Mendel (32) also demonstrated the necessity of lysine for the growth of chickens.

In view of the essential rôle which the basic amino acids play in nutrition as brought out above, it is reasonable to assume from a survey of the analytical results of cottonseed meal secured in this investigation that the proteins of this feedingstuff have a high nutritive value. The combined arginine and histidine content of cottonseed meal is greater than that of any other feedingstuff so far analyzed with the exception of the peanut. This feature alone is of great importance in view of the fact that arginine and histidine seem to be interchangeable in nutrition. While the lysine content cannot be said to be exceptional in any particular it seems apparent from the above discussion, that the combined proteins of cottonseed meal contain sufficient amounts of both cystine and lysine to render them adequate for nutrition.

Comparison with previous analyses of cottonseed meal. As shown in the introduction, there are but few determinations of the chemical composition of the proteins of cottonseed meal. The earliest studies were made upon one of the isolated proteins, the globulin or "edestin" of cottonseed, the results of which can not well be compared to analyses of the combined

proteins, since, as previously mentioned, the globulin contains but 42.3 per cent of the total nitrogen of cottonseed meal. In the accompanying table 5, the values secured by two previous investigators who made analyses of the combined proteins of cottonseed meal are brought together for comparison with those obtained in this investigation.

It is evident from the results presented that there is a general agreement between the three sets of values, but that there are considerable differences in several important particulars. As pointed out in the introduction, Nollau (10) calculated his results upon the total nitrogen content of the hydrolyzed solution after filtering off the solid residue insoluble in hydrochloric

TABLE 5

Distribution of nitrogen in cottonseed meal as determined by different investigators

(Results expressed in percentage of the total nitrogen of the feeding stuff)

INVESTIGATOR	HUMIN N	AMMONIA N	ARGININE N	CYSTINE N	HISTIDINE N	LYSINE N	AMINO N IN FILTRATE FROM BASES	NON-AMINO N IN FILTRATE FROM BASES	TOTAL N ACCOUNTED FOR
Nollau	6.27	14.06	12.77	2.74	7.57	1.94	45.02	7.49	97.48
Grindley	7.78	10.45	19.52	0.65	5.47	4.78	42.82	5.43	96.90
Nevens	6.58	9.49	18.74	0.91	7.40	3.81	40.12	2.68	98.75[1]

[1] Includes 9.03 per cent N removed in preliminary extractions plus uncharacterized nitrogen lost in method of analysis.

acid. This means that all of his calculations are too high, since a part of the nitrogen of the sample was undoubtedly discarded in the solid residue. The value of 6.27 per cent humin nitrogen reported by Nollau must, therefore, represent the soluble humin nitrogen, which is nearly as large a value as that obtained by the writer for the sum of the insoluble humin nitrogen plus the soluble humin nitrogen. The amount of soluble humin nitrogen found by the writer was but 3.89 per cent. Compared to the total humin nitrogen found by Grindley, et al. (9), the amount of total humin nitrogen as determined by the writer was 1.19 per cent less. The reduction of the humin nitrogen has no doubt been an important contributing

factor in the present investigation in securing somewhat higher values of the basic amino aids. In view of the known effects of acid hydrolysis of the proteins in the presence of carbohydrates, as already pointed out, it is reasonable to assume that the smaller amount of nitrogen discarded in the form of humin in these experiments than in those of Grindley may be attributed to the more complete separation of the proteins from the carbohydrates before hydrolysis.

The method of analysis of the proteins after hydrolysis by hydrochloric acid, as employed by Grindley et al., was similar to that employed by the writer, the main point of difference between the complete procedures being in the omission by the former workers of the extractions previous to hydrolysis. At just what point the 6.106 per cent of nonprotein nitrogen removed by the writer in the preliminary extractions might appear were it not so removed, is not clear. However, the sum of the ammonia nitrogen, amino nitrogen and non-amino nitrogen in the filtrate from the bases, obtained by Grindley et al, is 6.414 per cent greater than the sum of the corresponding values obtained by the writer, so it is possible that these three forms of nitrogen as reported by the former comprise some nitrogen not derived from the proteins as such.

It is evident from the table that the nitrogen of the bases as found by Grindley and his coworkers are in much closer agreement with those obtained by the writer than those reported by Nollau. The latter's figures for arginine are obviously too low, while his cystine values are more than four times as great as those of Grindley et al. and three times as great as those of the writer. Accordingly, the lysine nitrogen values as calculated by Nollau are correspondingly too low. The values for the total nitrogen of the bases as found by the three investigators in the order given in the table are as follows: 25.02 per cent, 30.42 per cent and 30.84 per cent respectively, the last being nearly 0.5 per cent higher than previous determinations.

The total nitrogen accounted for in the three reports is likewise shown to be 97.86 per cent, 96.90 per cent and 98.75 per cent. The greater amount in the last case is evidently due in part

at least, to the inclusion of the determinations of the uncharacterized nitrogen lost at points were unavoidable losses occur in the method of analysis. These losses were not determined by the first two investigators.

Comparison of the distribution of nitrogen in cottonseed meal with that in other feedingstuffs. A comparison of the results of analysis of the proteins of cottonseed meal, as discussed above, with those obtained by Hamilton, Grindley and Nevens (33) for alfalfa hay, oats and corn is of value in studying the relative nutritive value of the proteins of these feedingstuffs, as well as the applicability of the general method of analysis to feedingstuffs which vary widely in composition. In the analysis of oats and corn an additional preliminary extraction, which involves the use of hot trichloracetic acid, is employed to remove the starch. This extraction is not necessary in the case of cottonseed meal and alfalfa hay on account of the absence of starch in the former, as stated by Withers and Fraps (34), and the relatively small amount of starch in the latter.

The first point of interest in contrasting these feedingstuffs, as may be noted by reference to table 6, is their content of nonprotein nitrogen. Oats contain more than twice as much nonprotein nitrogen as cottonseed meal, while alfalfa hay contains more than three times as much. Hart and Bentley (35) found that 23.5 per cent of the nitrogen of alfalfa hay is present in a water soluble form, while Grindley and Eckstein (16) found a value of 28.4 per cent for the same feedingstuff.

The amount of total humin is greatest in the case of alfalfa, a natural result, since the proteins are more difficultly extracted from those feedingstuffs containing large amounts of crude fiber. The amount of humin in the case of corn is very small indeed, considering the high percentage of carbohydrates in this cereal, and compares very favorably with the amounts of humin resulting from the hydrolysis of pure proteins as shown in table 3. Cottonseed meal occupies a medium position in respect to the proportion of humin nitrogen.

The most striking difference between these four feedingstuffs is in their basic amino nitrogen content. Cottonseed

TABLE 6

Comparison of the distribution of nitrogen in cottonseed meal with that in other feedingstuffs

(Results expressed in percentage of total nitrogen of the feedingstuff)

FEEDING-STUFF	NONPROTEIN NITROGEN				RESULTS OF THE VAN SLYKE ANALYSIS										NITROGEN LOST IN METHOD OF ANALYSIS							TOTAL
	Soluble in absolute ether	Soluble in absolute alcohol	In filtrate from colloidal iron	Total nonprotein nitrogen	Insoluble humin nitrogen	Soluble humin nitrogen	Ammonia nitrogen	Arginine nitrogen	Cystine nitrogen	Histidine nitrogen	Lysine nitrogen	Amino acid N in filtrate from bases	Non-amino acid N in filtrate from bases	Total nonprotein + results of Van Slyke analysis	N in residue after treatment with strong NaOH	In alcohol precipitate of hot 2 per cent CCl_3COOH extract	Unadsorbed humin (filtered from solution during decomposition of bases)	Soluble in amyl alcohol-ether mixture	In residue filtered from solution of bases	In residue filtered from solution of filtrate from bases	Total nitrogen lost	Total nitrogen accounted for
Alfalfa hay ...	0.550	1.848	16.692	19.090	3.690	4.481	7.364	7.996	0.991	3.931	4.434	38.032	2.511	92.520	2.519		1.161	0.611		0.441	4.732	97.252
Oats.....	0.569	1.225	11.129	12.926	3.013	2.516	11.422	11.647	0.944	5.796	2.841	42.137	3.860	97.100	0.132	0.127	0.664	0.746	0.209	0.025	1.903	99.004
Corn	0.326	1.368	8.135	9.829	1.235	2.303	11.936	8.725	1.072	4.832	2.200	46.704	7.216	96.052	0.136	0.276	2.698	0.481	0.191	0.065	3.847	99.899
Cotton-seed meal ..	0.125	0.545	5.436	6.106	2.699	3.890	9.485	18.736	0.906	7.397	3.807	40.124	2.677	95.827	0.492		1.252	0.875	0.228	0.076	2.923	98.750

meal, as already indicated, is exceptionally high in arginine nitrogen, but it is also much higher in its total basic nitrogen content than the other three feedingstuffs, the values for the four feedingstuffs being: alfalfa hay, 17.412 per cent; oats, 21.228 per cent; corn, 17.529 per cent; and cottonseed meal, 30.846 per cent. The sum of the arginine nitrogen and histidine nitrogen is more than twice as great in the case of cottonseed meal as in the case of alfalfa hay and nearly twice as great as that of corn. From the considerations presented above regarding the biological significance of the basic amino acids, it would be logical to assume that these wide differences in the chemical composition of the proteins of different feedingstuffs indicate similar differences in their nutritive value, though probably not in corresponding degree. This point is mentioned in another paper in connection with the discussion of the results of the feeding experiment conducted for the purpose of studying the nutritive value of the proteins of cottonseed meal.

Alfalfa hay contains the smallest proportion of mono-amino acid nitrogen, possibly owing to its high content of nonprotein nitrogen while corn is exceptionally high in its content of both mono-amino and non-amino acid nitrogen.

The largest amount of nitrogen lost in the method of analysis occurs in the case of alfalfa, which is accounted for largely in the nitrogen remaining in the residues after the preliminary extractions have been completed. The next largest amount is in the case of corn, where the bulk of the loss is due to unadsorbed humin. The nitrogen is extracted very completely from both oats and corn. Cottonseed meal occupies a medium position with respect to the nitrogen lost in the analytical procedure.

The total nitrogen accounted for in the case of the various feedingstuffs is a point worthy of special note. The total is least in the case of alfalfa and greatest with corn. Here again cottonseed meal occupies a medium position. In this rather long method of analysis, which involves many extractions, concentrations, precipitations, filtrations and transfers, and which at some stages renders the proteins subject to putrefaction unless care

is taken, only 0.101 per cent of the total nitrogen originally present in the sample of corn was not accounted for, a very remarkable result indeed.

An examination of the results of individual analyses of the four samples of alfalfa hay and six samples each of oats and corn which were averaged to obtain the values shown in table 6, brings out the fact that the analytical results in the case of each of these feedingstuffs show, on the whole, less variability than the values for the eight samples of cottonseed meal shown in table 2. At least two factors operated to effect the difference. The analyses of the first three feedingstuffs mentioned were conducted by persons experienced in the manipulation and execution of the Van Slyke analysis and the analyses used for the averages were selected from a number of analyses. The analyses of cottonseed meal were made by the writer who had had no previous experience in the conduct of the Van Slyke method, and the analyses presented in table 1 are the entire results of the work. These considerations are strong evidence that the method of analysis here described is of general application to feedingstuffs and may readily be carried out.

Summary of the discussion of the results of the chemical analysis of the proteins. The accuracy of the determination of the amino acid content of the proteins of cottonseed meal has been increased over that of previous methods by the removal of the nonprotein nitrogen before proceeding with the hydrolysis of the proteins.

The accuracy of the determination has been still further increased by the reduction of the humin substances formed as a result of the hydrolysis of the proteins.

The amount of arginine nitrogen is much higher than that in most other feedingstuffs. The sum of the four basic amino acids is about 0.5 per cent higher than values previously found for cottonseed meal.

The method of extraction employed was found to result in the removal of 99.5 per cent of the total nitrogen present in the feedingstuff.

The sum of the ammonia nitrogen and amino acid nitrogen fractions is 83.132 per cent of the total nitrogen, an amount comparable to the sum of the same fractions previously obtained from pure vegetable proteins.

Of the total nitrogen originally present in the sample of cottonseed meal, 98.75 per cent was accounted for by summation of the fractions obtained at different stages in the method of analysis, a proportion greater than any previously reported for the same feedingstuff.

The complete method of analysis outlined in this paper is believed to be of general application to feedingstuffs and may readily be executed with successful results.

The writer is greatly indebted to Dr. H. S. Grindley for many courtesies extended during the course of this investigation in addition to his constructive criticism and general supervision of the work. His thanks are also due Mr. T. S. Hamilton for advice regarding certain analytical procedures.

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METHODS OF CALCULATING ICE CREAM MIXES[1]

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To calculate an ice cream mix so as to obtain a definite fat and solids content, we must know the composition of the ingredients. The table on page 402 gives the approximate composition of the materials commonly used in ice cream mixes.

In order to do accurate work, the mix should be made up on the basis of weight and not by volume. However, ice cream is sold by the gallon, and as a result we think of the mix in terms of gallons. In order to convert gallons into weight we must know the weight of a gallon of mix.

The weight of a gallon of mix varies according to its composition. The easiest way of getting the weight is, of course, by actual weighing. However, if the composition of the mix is known, we can calculate the theoretical weight per gallon.

In this calculation we assume that butterfat has a specific gravity of 0.93; the serum solids, 1.58; the sugar and gelatine 1.58; and the water 1.00. If we have a mix containing 12 per cent fat and 36 per cent total solids, then in 100 grams of this mix we have:

12 grams fat occupying $\frac{12}{0.93}$ or 12.903 cc.

24 grams other solids occupying $\frac{24}{1.58}$ or 15.190 cc.

64 grams water occupying $\frac{64}{1.00}$ or 64.000 cc.

The 100 grams of mix occupying 92.093 cc.

Therefore the specific gravity of the mix will be $\frac{100}{92.093}$ or 1.0857. A gallon of water weighs 8.34 pounds, therefore a gallon of this mix will weigh 8.34×1.0857 or 9.05 pounds.

[1] Published with the approval of the Director of the Wisconsin Agricultural Experiment Station.

Gathering all these calculations into one general expression we get:

$$\frac{100}{\frac{\text{per cent fat}}{0.93} + \frac{\text{per cent s.n.f.*}}{1.58} + \frac{\text{per cent water}}{1.00}} \times 8.34 = \text{weight per gallon of mix.}$$

*Sugar, gelatine and milk solids not fat.

	FAT	MILK SOLIDS NOT FAT	TOTAL SOLIDS
	per cent	*per cent*	
Skim milk	0	8.9*	8.9
Milk	Test	8.5 per cent or (100 − per cent fat) × 0.089†	8.5 per cent + per cent fat or (0.911 × per cent fat) + 8.9‡
Cream	Test	(100 − per cent fat) × 0.089†	(0.911 × per cent fat) + 8.9
Evaporated milk	7.8	17.7	25.5
Condensed milk	8.0	20.0	28 − 40 wer cent sugar
Condensed skim milk	0	28 − 32 (varies)	28 − 32 (varies)
Skim milk powder	1.0	94.0	95.0
Butter	Test	1.0	Per cent fat + 1.0
Sugar	0	0	95.0
Gelatine	0	0	100.0
Flavoring extracts	0	0	0

* Usually we do not have an analysis of the skim milk so that in the calculations an assumption has to be made. It is assumed here that the solids content is 8.9 per cent for skim milk from mixed milk.

† If we assume a certain figure for the solids not fat in the skim milk then we can calculate the solids not fat in whole milk or cream as follows: Per cent s.n.f. = (100−per cent fat) × 0.089.

For example if we have 100 pounds of 25 per cent cream we have 25 pounds of butter fat and 75 pounds of skim milk. If the skim milk contains 8.9 per cent s.n.f then we will have 75 × 0.089 or 6.675 pounds of s.n.f. in the 100 pounds of cream or 6.675 per cent.

‡ The total solids of milk or cream will be the fat plus s.n.f. We concluded that the s.n.f. can be calculated as follows:

Per cent s.n.f. = (100 − per cent fat) × 0.089;

therefore the total solids must be:

Per cent fat + (100 − per cent fat) × 0.089.

By simplifying the expression we get:

Total solids = (0.911 × per cent fat) + 8.9.

CALCULATING A SIMPLE MIX

By a simple mix we mean one in which no condensed milk product is used, but where the total solids content of the mix is

incidental to the amount of fat furnished by the milk and cream, and the amount of sugar used.

PROCEDURE AND SAMPLE CALCULATION

Object. To prepare 100 pounds mix to contain 14 per cent fat, 14 per cent sugar, 0.5 per cent gelatine, and 0.5 per cent vanilla.

Procedure

Step I. Calculate weight of fat necessary.

$$100 \times 14 \text{ per cent} = 14 \text{ pounds fat}$$

Step II. Calculate weight of sugar, gelatine and vanilla.

	pounds.
100×14 per cent sugar	= 14.0
100×0.5 per cent gelatine	= 0.5
100×0.5 per cent vanilla	= 0.5
	Total = 15.0

Step III. Calculate weight of cream and milk necessary, total weight of mix minus weight sugar gelatine and vanilla.

$$100 - 15 = 85 \text{ pounds of cream and milk}$$

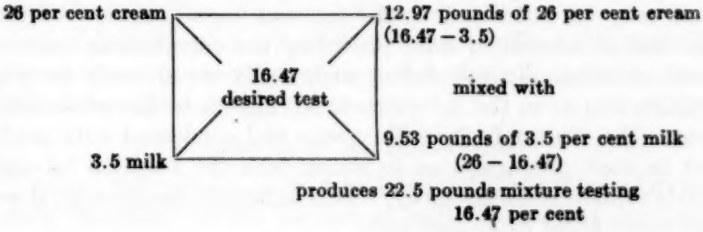
Step IV. Calculate the necessary fat test of the milk and cream mixture.

$$\frac{\text{Pounds of fat required}}{\text{Weight of cream and milk}} \times 100 = \text{fat test}$$

$$\frac{14.00}{85.0} \times 100 = 16.47 \text{ per cent}$$

Step V. Calculate the amount of cream and milk to mix to produce the required weight of mixture at the required fat test. This is best done by the Pearson square method.

Let us assume we have a 26 per cent cream and 3.5 milk.



However, we do not want 22.5 pounds, but 85 pounds. Therefore we must take $\frac{85}{22.5}$ or 3.778 times as much milk and cream.

12.97 pounds cream $\times$ 3.778 = 49.0 pounds cream
9.53 pounds milk $\times$ 3.778 = 36.0 pounds milk

Step VI. Tabulate the amounts of ingredients and calculate how much fat and solids each contributes, making use of the table of composition given above.

	FAT	SOLIDS
	pounds	*pounds*
49.0 pounds cream	12.74	15.93*
36.0 pounds milk	1.26	4.32†
14.0 pounds sugar	0	13.30‡
0.5 pounds gelatine	0	0.50
0.5 pounds (8 ounces) vanilla	0	0
	14.00 or 14.0 per cent	34.05 or 34.05 per cent

* Per cent solids in cream = (0.911 $\times$ per cent fat) plus 8.9.
† Per cent solids in milk = 3.5 per cent fat plus 8.5 per cent s.n.f.
‡ Per cent solids in sugar = 95 per cent.

After the recipe has been calculated, the daily calculations start with step IV. As the cream and milk tests vary, they will have to be mixed in different proportions to get the required amount of mixture at the desired test (in our illustration 85 pounds of milk and cream mixture testing 16.47 per cent fat).

COMPLEX ICE CREAM MIXES

In a simple ice cream mix we are satisfied with the solids content that may be incidental to the fat and sugar content. With the use of condensed milk products, the calculations become more complex. In calculating such a mix we not only have a definite aim as to the fat content, but also as to the solids content. We must mix the milk, cream and condensed milk product in such proportion as to obtain both the required fat and solids content simultaneously. This is further complicated if we use a sweetened condensed milk.

In attempting to proportion the amounts of three ingredients to obtain a given weight of mixture of a certain fat and solids content, the method that suggests itself at once is to make use of algebra and solve this problem by the use of simultaneous equations. For example if we wish to make 100 pounds of a mixture of cream, milk, and evaporated milk, to contain 16 per cent fat and 27 per cent solids, and if the milk contains 3 per cent fat, 12 per cent total solids; the cream 28 per cent fat, 34.5 per cent total solids; and the evaporated milk 8 per cent fat, 26 per cent total solids, letting x represent the weight of milk, y the weight of cream, z the weight of evaporated milk, we can construct the following equations.

$$x + y + z = 100$$

$$\frac{3x + 28y + 8z}{100} = 16$$

$$\frac{12x + 34.5y + 26z}{100} = 27$$

Having these three simultaneous equations we can solve for the three unknowns.

This kind of a calculation will obtain the desired results but is too complex to be of any practical use.

In the absence of any definite practical methods for calculating complex mixes exactly, the practice has been to resort more or less to guesswork, estimating the amount of condensed milk product to use and furnishing the remainder of the fat by milk and cream. If the total solids content figured out from this was too far from the desired amount, the mix would have to be recalculated and this repeated until after numerous trials the desired composition was approximated.

The following method has been devised to relieve this situation. By means of this method guesswork is eliminated and an exact calculation given in its place.

DERIVATION OF THE METHOD

In any mix we can easily calculate the fat and total solids contents necessary in the mixture of milk, cream and condensed

milk product, so that when the sugar, gelatine and vanilla are added it will be diluted down to the exact fat and solids content desired in the finished mix. The problem in a complex mix is to mix the cream, milk, and condensed milk product in the proper proportions.

If we mix cream and evaporated milk in such proportions that the mixture has a given fat test, the total solids content of the mixture will depend upon the richness of the cream used. The following examples will illustrate this.

If we mix 40 per cent cream and evaporated milk (7.8 per cent fat, 25.5 per cent total solids) in such proportions that we get a mixture testing 15 per cent fat, the mixture will contain 29.59 per cent solids.

If we use 20 per cent cream instead of 40 per cent cream the mixture containing 15 per cent fat will contain 25.86 per cent solids.

Mixture 1

	FAT	SOLIDS
	pounds	*pounds*
7.2 pounds 40 per cent cream.....	2.88	3.164
25.0 pounds evaporated milk.....	1.95	6.375
32.2 pounds mixture containing.....	4.83 or 15.0 per cent	9.539 or 29.5 per cent

Mixture 2

	FAT	SOLIDS
	pounds	*pounds*
7.2 pounds 20 per cent cream.....	1.44	1.880
5.0 pounds evaporated milk.....	0.39	1.275
12.2 pounds mixture containing.....	1.83 or 15.0 per cent	3.155 or 25.86 per cent

From the above figures it is seen that both mixtures have the same fat content; but where the richer cream was used the solids content is higher. It follows that the secret of getting the desired fat and solids contents simultaneously lies in deter-

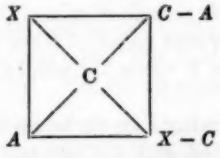
mining the necessary fat content of the cream, which, when thinned down (with regard to the fat) by the condensed milk product will give you both the desired fat and a solids contents.

Since we wish to mix cream and a condensed milk product in such proportions to obtain both a definite fat and solids content, we can momentarily look at the problem from two different viewpoints: (1) we can determine the proportion of cream to condensed milk product necessary to obtain the desired fat content; (2) we can determine the proportion of cream to condensed milk product to obtain the desired solids content. However, if these two, the fat and solids contents, are to be obtained simultaneously in the mixture it is necessary that these two proportions be equal. This is possible only for one particular fat content in the cream. By equating those two proportions and having all the values known except the test of the cream, we can calculate the test of the cream necessary to obtain the fat and solids contents simultaneously.

To express this in the form of an equation let the following letters represent the composition of the products used:

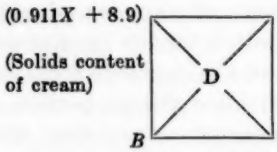
A = fat content of condensed milk product.
B = solids content of condensed milk product.
C = desired fat content in the mixture.
D = desired solids content in the mixture
X = fat test of the cream.

By means of Pearson's Square Method we can calculate the proportion of cream to condensed milk product necessary to obtain the desired fat content in the mixture.



From this it is seen that the proportion in which the cream testing X must be mixed with the condensed milk product testing A per cent fat to obtain fat content C is $\frac{C-A}{X-C}$.

Similarly we can calculate the proportion in which these two ingredients must be mixed to obtain the desired total solids content.



(Solids content of condensed milk product)

The proportion in which the cream testing X per cent fat must be mixed with the condensed milk product testing B per cent solids to obtain the solids content D is $\frac{D-B}{0.911X+8.9-D}$

On equating these two proportions we have:

$$\frac{C-A}{X-C}=\frac{D-B}{0.911X+8.9-D}$$

On simplifying this expression by multiplying and transposing the following equation results:

$$X=\frac{BC+8.9A-8.9C-AD}{0.911C+B-0.911A-D}$$

By means of this equation the necessary cream test can be calculated; so that when this cream is mixed with the condensed milk product in the proper proportion to obtain the desired fat test, the desired solids content is obtained simultaneously.

PROCEDURE AND SAMPLE CALCULATION

Object. To prepare 100 pounds of mix of the following composition: 12.2 per cent fat, 13.0 per cent sugar, 37.0 per cent total solids, 0.5 per cent gelatine dissolved in 6 times its weight of water, 0.5 per cent vanilla.

The following dairy products are to be used: 3.5 per cent milk, 32.0 per cent cream, evaporated milk 8.0 per cent fat, 26 per cent solids.

Procedure

Step I. Calculate the weight of fat necessary.

100 × 12.2 per cent = 12.2 pounds fat

Step II. Calculate the weight of sugar, stabilizer, and vanilla necessary.

100 × 13.0 per cent sugar	=	13 pounds sugar
100 × 0.5 per cent gelatine	=	0.5 pounds gelatine
100 × 3.0 per cent water to dissolve gelatine	=	3.0 pounds water
100 × 0.5 per cent vanilla	=	0.5 pounds vanilla
	Total =	17.0 pounds.

Step III. Calculate the actual weight of solids in the above:

13 pounds sugar × 95 per cent	=	12.35
0.5 pounds gelatine equals 100	=	0.5
0.5 pounds vanilla × 0.00	=	0.0 pounds.
	Total =	12.85 pounds solids

Step IV. Calculate the total weight of solids necessary

100 × 37 per cent = 37.0 pounds solids

Step V. Calculate the weight of solids to be furnished by the milk, cream and condensed milk product

37 − 12.85 = 24.15 pounds milk solids

Step VI. Calculate the weight of milk products.

100 − 17.0 = 83.0 pounds of milk, cream, etc.

Step VII. Calculate the fat test necessary so that the weight of milk products (Step VI) will furnish the weight of fat needed (Step I)

$$\frac{12.2}{83.0} \times 100 = 14.70 \text{ per cent fat.}$$

Step VIII. Calculate the solids test necessary so that the weight of milk products (Step VI) will furnish the weight of milk solids needed (Step V)

$$\frac{24.15}{83.0} \times 100 = 29.096$$

Step IX. Calculate the test of the cream necessary so that when the condensed milk product is added the desired fat and solids contents are obtained simultaneously. Use the formula derived above

$$X = \frac{BC + 8.9\,A - 8.9\,C - AD}{0.911\,C + B - 0.911\,A - D}$$

A = 8.0 (The fat in the evaporated milk)
B = 26.0 (The solids in the evaporated milk)

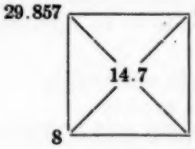
C = 14.70 (The desired fat test in the mixture)
D = 29.096 (The desired solids in the mixture)
X = the test of cream to be found
Substituting these values in the equation:

$$X = \frac{(26.0 \times 14.70) + (8.9 \times 8.0) - (8.9 \times 14.70) - (8 \times 29.096)}{(0.911 \times 14.7) + 26.0 - (0.911 \times 8.0) - 29.096}$$

$$X = \frac{382.2 + 71.2 - 130.83 - 232.768}{13.3917 + 26 - 7.288 - 29.096}$$

$$X = \frac{89.802}{30.077} = 29.857 \text{ per cent}$$

Step X. Calculate the amounts of this cream and condensed milk product to use.

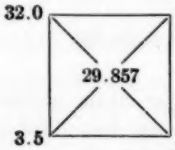


6.7 pounds of cream
plus
15.157 pounds of evaporated milk
produces 21.857 pounds of mixture testing 14.7 fat.

We want 83 pounds of mixture or $\frac{83}{21.857}$ or 3.797 times as much:

6.7 pounds cream × 3.797 = 25.44 pounds.
15.157 pounds evaporated milk × 3.797 = 57.56 pounds.

Step XI. Calculate the amount of cream and milk to mix to produce the thinner cream testing x per cent fat.



26.357 pounds cream
plus
2.143 pounds milk
produces 28.500 pounds of cream 29.857 per cent fat.

We want 25.44 pounds of cream or $\frac{25.44}{28.50}$ or 0.9 times as much.

26.357 × = 23.511 pounds of cream.
2.143 × 0.9 = 1.929 pounds of milk.

Step XII. Tabulate the mix as calculated, figure the amount of fat and solids each ingredient contributes, and obtain the totals.

	FAT	SOLIDS
	pounds	*pounds*
23.511 pounds cream 32 per cent	7.5235	8.9464
1.929 pounds milk 3.5 per cent	0.0675	0.2332
57.56 pounds evaporated milk	4.6048	14.9656
13.00 pounds sugar	0	12.3500
0.50 pounds gelatine	0	0.5000
3.00 pounds water	0	0
0.50 pounds vanilla	0	0
100.00 pounds	12.1958	36.9952

Note: The daily calculations start with Step XI and are very simple. After a recipe has once been figured out and the necessary fat test of the cream (the value of x in the formula) determined, it is only necessary each day to figure out how much of the particular milk and cream on hand to mix to get the desired weight of cream testing x.

A new recipe has to be figured only when a condensed milk product of different composition is used.

CALCULATING A MIX IN WHICH A SWEETENED CONDENSED MILK PRODUCT IS USED

The calculation of an ice cream mix is further complicated if we use a sweetened milk product. We are then adding sugar from two different sources, and we cannot tell how much sugar to add in a dry form until we know how much sweetened condensed milk we are going to use, and vice versa.

In order not to complicate the calculation unnecessarily the moisture content of the dry sugar is ignored. However, by a slight change in the calculation this could easily be taken into consideration.

In the use of sweetened condensed milk in a mix the calculations can be simplified and made exact, if we assume in our calculations that we can for the time being remove the sugar from the condensed milk. If we had 100 pounds of condensed milk containing 8 per cent fat, 30 per cent milk solids, and 40

per cent sugar, we would have 60 pounds of condensed milk left if the 40 pounds of sugar were removed. The fat and solids content of these 60 pounds of *hypothetical condensed milk* would be $\frac{60}{8} \times 100$ or $13\frac{1}{3}$ per cent of fat, and $\frac{30}{60} \times 100$ or 50 per cent solids.

In our calculations we shall deal with the *hypothetical condensed milk*, and after the amount has been calculated figure how much sugar will be associated with it, and take that much less crystalline cane sugar.

PROCEDURE AND SAMPLE CALCULATION.

Object. To prepare 100 pounds of mix of the following composition: 12 per cent fat, 13 per cent sugar, 36 total solids, 0.5 per cent gelatine dissolved in 5 times its weight of water, 0.5 per cent vanilla.

The following dairy products are to be used: Cream 25 per cent. fat, milk 3.5 per cent fat, sweetened condensed milk containing 8 per cent fat, 30 per cent milk solids and 40 per cent sugar.

Step I. Calculate the weight of fat necessary:

100 × 12 per cent fat equals 12 pounds fat

Step II. Calculate the weight of sugar stabilizer and vanilla necessary:

100 × 13 per cent sugar	= 13	pounds sugar
100 × 3 per cent gelatine solution	= 3	pounds gelatine solution
100 × 0.5 per cent vanilla	= 0.5	pounds vanilla
	Total = 16.5	pounds

Step. III. Calculate the actual weight of solids in the above:

13.0 pounds sugar	= 13	pounds solids
3.0 pounds gelatine solution	= 0.5	pounds solids
0.5 pounds vanilla	= 0.0	pounds solids
	Total = 13.5	pounds solids

Step IV. Calculate the total weight of solids necessary:

100 x 36 per cent solids = 36 pounds solids

Step V. Calculate the weight of solids to be furnished by the milk cream and condensed milk product:

36 − 13.5 = 22.5 pounds solids

Step VI. Calculate the weight of milk products:

$$100 - 16.5 = 83.5 \text{ pounds}$$

Step VII. Calculate the fat test necessary so that the weight of milk products (Step VI) will furnish the weight of fat needed (Step I):

$$\frac{12}{83.5} \times 100 = 14.371 \text{ per cent fat}$$

Step VIII. Calculate the solids content necessary so that the weight of milk products (Step VI) will furnish the weight of solids needed (Step V):

$$\frac{22.5}{83.5} \times 100 = 26.946 \text{ per cent solids}$$

Step IX. Calculate the test of cream necessary so that when the condensed milk product is added the desired fat and solids contents are obtained simultaneously:

$$X = \frac{BC + 8.9A - 8.9C - AD}{0.911C + B - 0.911A - D}$$

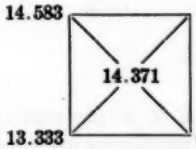
A = 13⅓ per cent (the fat in the hypothetical condensed milk)
B = 50 per cent (The solids in the hypothetical condensed milk)
C = 14.371 per cent (the desired fat in the mixture)
D = 26.946 per cent (the desired solids in the mixture)
X = the fat test of the cream

$$X = \frac{(50 \times 14.371) + (8.9 \times 13\tfrac{1}{3}) - (8.9 \times 14.371) - (13\tfrac{1}{3} \times 26.946)}{(0.911 \times 14.371) + 50 - (0.911 \times 13\tfrac{1}{3}) - 26.946}$$

$$X = \frac{718.550 + 118.666 - 127.902 - 359.280}{13.092 + 50 - 12.146 - 26.946}$$

$$X = \frac{350.034}{24.000} = 14.583$$

Step X. Calculate the amounts of this cream and condensed milk product to use:



1.038 pounds cream

0.212 pounds hypothetical condensed milk

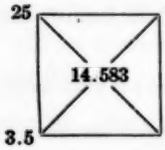
1.250 pounds mixture.

We need $\frac{83.5}{1.25}$ or 66.8 times as much:

$1.038 \times 66.8 = 69.34$ pounds cream

$0.202 \times 66.8 = 14.16$ pounds hypothetical condensed milk.

Step XI. Calculate the amount of cream and milk to mix to produce the thinner cream testing × per cent fat:



11.083 pounds cream

10.417 pounds milk

21.500 pounds mixture

We need $\frac{69.34}{21.5}$ or 3.225 times as much:

$11.083 \times 3.225 = 35.75$ pounds cream

$10.417 \times 3.225 = 33.59$ pounds milk

Step XII. Tabulate the mix as calculated, figure the amount of sugar associated with the calculated amount of *hypothetical condensed milk*, the amount of dry sugar to use, and the amount of fat and solids in the entire finished mix. The figures thus far obtained are:

35.75 pounds cream 25 per cent
33.59 pounds milk 3.5 per cent
14.16 pounds hypothetical condensed milk
13.00 pounds sugar
3.00 pounds gelatine solution
0.50 pounds vanilla extract

To convert the weight of *hypothetical condensed milk* into the corresponding weight of actual condensed milk we have to calculate as follows:

$$\frac{\text{Weight of hypothetical condensed milk} \times 100}{100 - \text{sugar content of condensed milk}} = \text{weight of condensed milk}$$

$$\frac{14.16 \times 100}{100 - 40} = 23.6 \text{ pounds of condensed milk}$$

This weight of condensed milk contains 23.6×40 per cent or 9.44 pounds of cane sugar, therefore instead of 13.0 pounds we must use $13.0 - 9.44$ or 3.56 pounds of cane sugar.

On tabulating the completed calculation we have:

	SUGAR	FAT	SOLIDS
	pounds	*pounds*	*pounds*
35.75 pounds cream 25 per cent	0	8.938	11.324
33.59 pounds milk 3.5 per cent	0	1.176	4.061
23.60 pounds condensed milk	9.44	1.888	16.520
3.56 pounds sugar	3.56	0	3.560
3.00 pounds gelatine solution	0	0	0.500
0.50 pounds vanilla extract	0	0	0
100.00 pounds	13.00	12.002	35.965

SUMMARY AND CONCLUSIONS

1. A table giving the approximate composition of materials commonly used in ice cream mixes is given.

2. It is recommended that mixes be calculated on the basis of a hundred pounds.

3. The method of calculating the theoretical weight of a gallon of ice cream mix is explained.

4. A method is derived and sample calculations are given for calculating complex ice cream mixes.

5. The method given is in itself not very short, but it is recommended as practical, because it is used only in calculating new recipes. The entire calculations do not have to be repeated every day.

DAIRY PRODUCTS INVESTIGATIONAL PROJECTS CARRIED ON BY THE AGRICULTURAL EXPERIMENT STATIONS IN 1919

ROY C. POTTS

Bureau of Markets, United States Department of Agriculture, Washington, D. C.

This list was compiled from a 225 page mimeographed booklet of Experiment Station Projects prepared in the office of Experiment Stations of the United States Department of Agriculture. Supplementing it is a statement of the dairy products activities undertaken by the Dairy Division of the Bureau of Animal Industry and the Dairy Marketing Division of the Bureau of Markets of the United States Department. This list of dairy activities of the State Agricultural Experiment Stations and the United States Department of Agriculture should be of interest to the members of the American Dairy Science Association, for it indicates, in general the various phases of the dairy products industry to which the dairy investigators of this country are giving particular attention. This list should be studied carefully, for it may suggest possible opportunities for coördination of work and coöperation among workers in obtaining better results, also a need of investigations of certain important phases which are entirely omitted or ignored at present.

This list is for the year 1919. Why could not this association compile a list of the 1920 projects also those proposed for 1921? Who shall undertake that task? The editor-in-chief, would appreciate your views on this proposition.

LIST OF STATE AGRICULTURAL EXPERIMENT STATION DAIRY PRODUCTS PROJECTS

Chemical studies of dairy products

1. Study of the properties of pure casein. N. Y. State.
2. Study of carbonic acid in milk. N. Y. State.

3. Study of the chemistry of butterfat and the effect of food in modifying its chemical and physical character. Mass.
4. Method for preliminary detection of abnormal milk. N. Y. State.
5. Method of determination of keeping quality of milk. N. Y. State.

Nutrition studies of dairy products

1. Role of dairy products in practical nutrition. Okla.
2. Food value of various milks for infants and invalids. Maryland.
3. Nutritive value of milk for children and animals. Vermont.
4. Minimum quantity of butterfat necessary to produce normal development in young growing animals. Ore.

Bacteriological studies of dairy products

1. Investigations in connection with raw and manufactured dairy products. Mich.
2. The influence of barn factors on the germ content of milk. Ill.
3. Species of bacteria found in dairy utensils. N. Y. Cornell.
4. The important factors in the production of sanitary milk and the means and methods on milk examination. N. Y. State.
5. Bacteriological examinations of certified milk. Calif.
6. A study of the true accuracy of bacterial counts as made from milk. N. Y. State.
7. The determination of the bacterial content of milk by a rapid method (little plate method). Wis.
8. The bacteria content of milk from milking to cooling. S. C.
9. Studies on cooling of milk in relation to its bacterial quality. N. Y. State.
10. The American high acid organisms found in milk. Iowa.
11. Acid production and the rate of growth of the lactic acid organism in the souring of milk. N. Y. State.
12. Studies on the bacterial flavors and odors of milk.
13. A study of the torula forms responsible for the yeasty fermentation in cream. Iowa.
14. The effect of preservatives on the bacteria in milk. Penn.
15. The use of available chlorin as a germicide in milk and milk products. Ark.
16. The bacteriology of butter. Okla.
17. A chemical and bacteriological study of the keeping qualities of butter. Ind.

18. A study of mold development on butter. Calif.
19. A study of the types or organisms present and multiplying in cottage cheese. Idaho.
20. Studies on the relation between the bacterial flora of good quality cheese and of good quality milk. N. Y. State.
21. Studies of the compounds in cheese and their changes under the influence of certain classes of bacteria. N. Y. State.
22. Chemical and bacteriological studies of ice cream. Ind.

Studies of butter and butter making

1. Influence of acidity of cream on flavor and keeping qualities of resulting butter. Iowa.
2. The neutralizing of the acidity of cream for buttermaking. Ore.
3. The effect of neutralization on the quantity of butter. N. Y. Cornell.
4. The chemistry of churning. Miss.
5. The cause of difficult churning. Wash.
6. Factors influencing grade of butter. Okla
7. A study of California butter at the Davis and San Francisco Markets. Calif.
8. Comparison of creamery and market weights of butter. Wis.
9. Study of dairy plant records. N. Y. Cornell.
10. Creamery building and improvement. N. C.
11. Keeping qualities of butter. Mich.
12. Keeping qualities of butter in storage as affected by methods in making.
13. A chemical and bacteriological study of the keeping qualities of butter. Ind.
14. A study of mold development on butter. Calif.
15. Scoring contests of commercial creamery butter. Idaho.
16. The bacteriology of butter. Okla.

Studies of cheese and cheese making

1. Mountain cheese work. N. C.
2. Making cheese. N. C.
3. Cheese investigations. Wis.
4. A study of the manufacture of cheese and whey. Calif.
5. Studies of the compounds in cheese and their changes under the influence of certain classes of bacteria. N. Y. State.
6. Factors concerned in the coagulation of milk by heat. Wis.

7. Yield of cheese from milk high and low in fat. Wis.
8. Pasteurization of milk for cheese making. N. Y. Cornell.
9. The effect of clarifying milk for making Cheddar cheese. N. Y. Cornell.
10. Studies in cheese making. Effect of temperature of cooking on texture of cheese; effect of amount of rennet or pepsin on rapidity of curing cheese; the possibility of curing cheese in Oklahoma factories; controlling factors in proper handling and marketing of cheese in Oklahoma. Okla.
11. The effect of separating temperatures on the loss of fat in separated whey. Oregon.
12. Studies on the relation between the bacterial flora of good quality cheese and of good quality milk. N. Y. State.
13. A study of the types of organisms present and multiplying in cottage cheese. Idaho.
14. A study of the control of mold development in cheese-curing rooms. Calif.
15. The use of *Bacillus bulgaricus* starter for controlling gassy milk in the manufacture of Cheddar cheese. Calif.
16. The effect of washing curd on the yield and quality of Cheddar cheese. N. Y. Cornell.
17. The use of pepsin as a substitute for rennet in the manufacture of California (granular) and Cheddar cheese. Calif.
18. Studies in the manufacture of Swiss cheese in vats. Ore.
19. The manufacture of Camembert, Swiss, and albumin cheeses. N. Y. Cornell.
20. Cheese making.—(Cottage, Neufchatel, whey, Romano, Etc.) A study of the practice of cheese making with special reference to the manufacture of foreign cheeses. Vt.
21. Relation of moisture and acidity to keeping quality of Neufchatel and cream cheeses. N. Y. Cornell.
22. The manufacture of cottage cheese from a mixture of skim milk using *Bacillus bulgaricus* starter for curdling the milk. Calif.
23. The manufacture of a skim milk cheese that will keep. S. Dak.

Cream production studies.

1. A study of some factors affecting the texture of the cream. Calif.
2. Losses in farm skimming of cream. N. C.
3. Factors affecting the efficiency of hand separators and causes of variation in cream tests. Nebr.

4. A study of the efficiency of the various cream cooling tanks. Nebr.
5. Cream routes. N. C.
6. An investigation regarding the whipping of cream. Wash.
7. A study of the Torula forms responsible for the yeasty fermentation in cream. Iowa.

Ice cream studies

1. Ice cream investigations. Kan.
2. Studies in ice cream making. Okla.
3. Commercial ice cream making. Okla.
4. Testing ice cream for butter fat. A comparison of various acids as to time required, case of manipulation, character and accuracy of test; comparison of different ingredients upon character of test, such as sugar, gelatin, gum tragacanth, and ice cream powder, fruits, eggs, and color material; influence of method of obtaining samples, time cream has been packed and manner of packing; comparison of results with cream and milk bottles; effect of emulsifying and homogenizing upon ease with which tests may be made. Okla.
5. Chemical and bacteriological studies of ice cream. Ind.
6. A study of the factors affecting swell in ice cream. Calif.
7. Factors affecting the formation of ice crystals in ice cream. N. Y. Cornell.
8. Fillers in the manufacture of ice cream. Wash.

Studies of milk secretion, composition and supply

1. An investigation of physiological and chemical changes taking place within the mammary gland during secretion. Md.
2. Certain problems relating to the biochemistry of milk formation in the udder. N. Y. State.
3. Milk secretion studies, using condemned tubercular cattle. The study of the source of milk solids. Vt.
4. Synthetic capacity of the mammary gland. Wis.
5. Feeding galactose to dairy cattle. Del.
6. The influence of barley on the milk secretion of cows. Calif.
7. Investigations into causes of variation in milk and fat production. Effect of individuality of cows upon milk and fat yields. Influence of alimentary carbohydrates on the yield and composition of milk. Effect of proteins from restricted sources on the yield and composition of milk. Iowa.

8. Factors influencing or affecting the chemical and physical properties of milk. Miss.
9. Analysis of milk records. To determine the age changes and the duration between total solids-not-fat and milk production, per cent fat, and butter fat. Maine.
10. Factors influencing the composition of milk; the influence of the plane of nutrition of the cow. Missouri.
11. A study of the composition of milk and fat—as affected by feeds, from different breeds of cows, and with reference to the natural quantitative relationship existing between the various constituents of milk. Ohio.
12. Study of the chemistry of butter fat and the affect of food in modifying its chemical and physical character. Mass.
13. The effect of peanut meal when fed to dairy cows on the qualities of the butter fat, and methods by which this feed may be fed without undesirable effects. Ga.
14. Study of carbonic acid in milk. N. Y. State.
15. Carbonic acid in milk under various conditions after being drawn from the udder, and carbonic acid content as a basis for distinguishing between heated and unheated milk. N. Y. State.
16. Carbonic acid and carbonates in the udder. N. Y. State.
17. Acidity of fresh milk. N. Y. Cornell.
18. Conditions affecting hydrogen-ion concentration in milk. N. Y. State.
19. Acid production and the rate of growth of the lactic acid organism in the souring of milk. N. Y. State.
20. Investigation in the eradication of onion flavors from milk. N. C.
21. The enzymes of milk and their relation to abnormal flavors. Mo.
22. Studies on the bacterial flavors and odors of milk. Iowa.
23. The toxicity of milk. (?)
24. Effect of diseases in the cow on milk. Mich.
25. The investigation of the food value for infants and invalids of various milks. Md.
26. Studies regarding the nutritive value of milk, its suitability for food for children and animals, conditions which affect its nutritive value, tolerance, and related questions. Vt.
27. Study of city milk supply. N. Y. Cornell.
28. Studies on method of controlling and standardizing the quality of market milk. N. Y. State.

29. The important factors in the production of sanitary milk and the means and methods of milk examination. N. Y. State.
30. Study in the quality of milk. Ore.
31. Tests for pasteurized milk. Wis.
32. Studies of minor factors in market milk distribution. Mich.
33. A study of the milk and cream supply furnished to the University Farm Creamery, with the object of working out a system of grading and paying for quality. Calif.
34. The marketing of dairy products, in Oklahoma. To ascertain general prices of butter fat, of milk and cream in all sections of the state at four periods of the year. The kind of market available; amount of butter fat, milk or cream offered for sale at centers in all sections of the State, methods of marketing, and form in which butter fat is marketed; frequency of market and the factors determining prices. Okla.
35. Shipments of dairy products in New York State. N. Y. Cornell.
36. Study of plant records. N. Y. Cornell.
37. The production, handling and marketing of milk and the making of butter under tropical conditions, Dairying in the tropic. Porto Rico.

Studies in milk testing

1. Official dairy testing. N. Dak. Wash.
2. Advanced registry testing. Va.
3. Comparison of fat tests made by cow testing associations and local creamery. N. Y. Cornell.
4. Composite *v.* one day testing of milk samples. N. C.

Studies of cost of milk production and accounting

1. Cost of milk production. Conn. Storrs. N. Dak. Ohio.
2. Cost of milk production in Nebraska. Nebr.
3. Procuring data relative to the cost of producing market milk. Mich.
4. Cost of milk production and dairy farm organization. Wash.
5. Cost of milk from forced *v.* averaged dairy condition cows. Md.
6. Records of production, cost of feeding, and cost of milk production in tests of advanced registry of dairy cows. To secure records of production of registered dairy cows in Oklahoma; to secure feed records and methods of feeding dairy cows when under official test; to determine the cost of feeding test cows in Oklahoma; to determine cost of production of milk in tests of advanced registry to owners or breeders of dairy cows. Okla.

7. Cost of producing dairy products. Minn.
8. Method and cost of distributing milk, with special reference to Oakland, Alameda, and Berkeley, Calif.
9. A study of the animal cost of the production of milk for the city supply and of butter fat for the creamery. Ill.
10. Dairy farm organization and cost of milk production. Wash.

Dairy Products Activities of the Dairy Marketing Division of the Bureau of Markets of the United States Department of Agriculture

(For the year 1919–1920 and 1921)

Investigational activities

Methods and cost of marketing dairy products

1. Methods of butter marketing by wholesalers and jobbers.
2. Methods of cheese marketing by wholesalers and jobbers.
3. Methods and costs of supplying cities with market milk and cream.
4. Methods of marketing cottage cheese by manufacturers and retailers.
5. Plan of organization and functions performed by producers dairy marketing organizations.

Market grades and standards for dairy products

1. Market grades and standards for creamery butter.
2. Market grades and standards for American (Cheddar) cheese.
3. Market grades and standards for cream.
4. Market grades and standards for market milk.
5. Market grades and standards for Swiss and brick cheese.

Inspection service activities

Market inspection service

1. Butter inspection service maintained in the Boston, Chicago, New York and Philadelphia markets under act of Congress known as the Food Products Inspection Act.
2. Informal inspections made of cheese in the New York markets.
3. Informal tests made of weight of shipments of butter at Boston, Chicago, New York and Philadelphia.

Market reports and market information

Dairy statistics (supplies and stocks)

1. Monthly reports of imports and exports of butter, cheese, condensed and evaporated milk, casein and milk powder.
2. Monthly reports (issued quarterly) of production of whey and creamery butter, American cheese, Swiss cheese, brick and Munster cheese, Limburger cheese, Cottage, pot and bakers' cheese, cream and Neufchatel cheese, all Italian varieties of cheese, and all other varieties of cheese, dried casein, all classes of condensed and evaporated milk, evaporated milk modified with foreign fat, condensed and evaporated butter milk, dried or powdered buttermilk, desiccated or powdered milk, malted milk, milk sugar and ice cream. Reports are also issued monthly on the production of process butter and oleomargarine.
3. Monthly reports of stocks of creamery butter, packing stock butter, American cheese, Swiss cheese, brick and Munster cheese, Limburger cheese, Cottage, pot or bakers' cheese, cream and Neufchatel cheese, and all other varieties of cheese in cold storage.
4. Monthly stocks of condensed and evaporated milk in hands of manufacturers, including separate figures for total and unsold stocks, unfilled orders, and unsold stocks held in New York City.
5. Daily receipts of butter and cheese at Boston, Chicago, New York, Philadelphia and San Francisco.
6. Daily movement of butter and cheese into and out of storage at Boston, Chicago, New York, Philadelphia and San Francisco.
7. Daily stocks of butter held as current trading stocks by wholesale butter dealers in Boston, Chicago, New York, Philadelphia and San Francisco.
8. Weekly reports of stocks of cheese held as current trading and storage stocks by cheese dealers in Boston, Chicago, New York, Philadelphia, San Francisco, and by primary market cheese dealers (over 90) in Wisconsin.

Prices of dairy products

1. Daily wholesale and jobbing prices of butter in Boston, Chicago, New York, Philadelphia, and San Francisco.

2. Daily wholesale prices of Number one American cheese (all styles) in Boston, Chicago, New York, Philadelphia, San Francisco and primary cheese markets in Wisconsin.
3. Monthly reports of prices paid milk producers for milk for city distribution in over 100 cities in the United States.
4. Monthly report of average prices paid milk producers for milk by condenseries in the various geographical sections of the United States.
5. Wholesale and retail prices of market milk and cream in over 100 cities in the United States.
6. Monthly report of average prices of condensed and evaporated milk in the various geographical sections of the United States.

Condition of markets for dairy products

1. Daily comments on butter markets, conditions in Boston, Chicago, New York, Philadelphia and San Francisco.
2. Daily comments on cheese market conditions in Boston, Chicago, New York, Philadelphia, San Francisco, and primary cheese markets in Wisconsin.
3. Weekly review of butter market conditions in the United States.
4. Weekly review of the cheese market conditions in the United States.
5. Monthly report of conditions in the condensed and evaporated milk market in the United States.

Research Activities of the Dairy Division of the Bureau of Animal Industry of the United States Department of Agriculture

(For the year 1919–20 and 1921)

Dairy research laboratory

1. Bacteria concerned in the ripening of Swiss cheese.
2. Utilization of lactose by fermentation.
3. Physiology, taxonomy and origin of the streptococci occurring in milk.
4. Manufacture and ripening of Roquefort cheese.
5. Manufacture and ripening of Camembert cheese.
6. Factors influencing texture of ice cream.
7. Utilization of whey for feeding purposes.
8. The precursors in the blood of milk proteins.

9. Bacteria concerned in the deterioration of condensed milk.
10. Influence of calcium and phosphorus deficiency on milk yield.
11. Factors influencing viscosity of condensed milk.
12. Methods of improving hand separator cream.
13. The manufacture and curing of the hard Italian cheeses.
14. The utilization of the albumen of whey.
15. Bacteria surviving sterilization in evaporated milk.
16. Factors influencing the coagulation of evaporated milk in sterilization.
17. The cause and control of sandiness in ice cream.
18. The cause and control of deterioration in milk powder.
19. Seasonal variation in milk for evaporating.
20. The influence of salts on the growth of bacteria.
21. Chemical and physical changes in milk coagulation.

Market milk section

1. Dairy sanitation:
   Sanitary surveys are made of milk supplies in various cities at the request of local officials.
2. Milk plant management:
   Studies are made of methods and costs of the various operations entailed in the handling and delivery of milk in cities.
   Special studies are made of some of the various specific problems the milk-plant manager meets.
3. Methods of cleaning milking machines:
   Studies as to the best methods of cleaning milking machines.
4. Milk transportation:
   Studies as to the best methods of transporting milk to the city with the least possible amount of loss from spoilage.
5. Special studies:
   Special studies of the various properties of milk products, such as, whipping quality of cream, etc.
6. Studies in the Unit Requirements for Producing Milk:
   Studies conducted for two years in each of seven different States.

Dairy extension section

(a) *Projects in cow testing association investigations*

1. Influence of production on income over cost of feed.
2. Relation of production to returns on $1.00 expended for feed.

3. Relation of production to feed cost per pound of butterfat.
4. Relation of production to feed cost per 100 pounds of milk.
5. Production as influenced by date of freshening.
6. Influence of size within the breed.
7. Effect of location.
8. Length of time large producers remain in the service, as compared with production period of low producers.
9. Decrease in production as lactation period progresses.
10. The cow as an economical producer of human food.
11. Increased production due to testing done by the association.
12. Relation between profit and the feeding of silage.
13. Relation between profit and the feeding of legumes.
14. The feeding of timothy.
15. Influence of pasture.
16. Summer dairying.
17. Daughters of purebred sires compared with the dams of the daughters.
18. Influence of age on production.
19. Production of milk and butterfat in relation to the butterfat test.
20. Variation in butterfat test due to season.
21. Variation in butterfat test due to point of lactation period.
22. Percentage of cows that fall below 3.25 per cent in the test.
23. Percentage of herds that test less than 3.25 per cent butterfat.
24. The tester and his work.

(b) *Investigations and study of coöperative bull associations*

1. Problems connected with methods of organization and development.
2. Study of the relative cost of bull service before and after organizing.
3. Studies of the results of the use of better bulls on herds belonging to members of bull associations.
4. Study and investigation of the problems and methods of handling vicious and unruly bulls as affecting the bull association organizations.
5. Study of the abortion disease as affecting bull association organizations.

(c) *Study of cheese and cheese making*

1. Mountain cheese work in mountains of the south.
2. Studies and problems involved in the introduction of Swiss and other foreign cheeses into commercial factories.

Dairy Division experiment farm

1. Effects of the various feeds and constituents of feed upon the animal body, upon growth, and upon the yield and composition of milk, and to find out the relative values of feeds for dairy production.
2. Effect of regular versus irregular milking.
3. Effect of milking two, three and four times per day.
4. Effect of keeping cows in stanchions versus box stalls.
5. Feed cost of raising heifers.
6. Raising calves on milk substitutes.
7. Feeding sweet potato meal to dairy cows.
8. Growing crops for the silo.

Breeding experiments (dairy cattle)

1. Comparing line breeding with the mating of unrelated animals; comparing in-breeding with the mating of unrelated animals, as a means of fixing high production in dairy cattle; also the effect of these methods of breeding on constitution, fertility and type.
2. An attempt to fix prepotency for high production by continued use of sires that have shown the ability to get high-producing daughters, for generation after generation.
3. Statistical study of the effect of methods of breeding on production, from advanced register and register of merit data.

Dairy manufacturing section

1. Study of butter manufacturing costs.
2. Study of condensed milk manufacturing costs.
3. Study of cottage cheese manufacturing costs.
4. Study of Camembert cheese manufacturing costs.
5. Study of Roquefort cheese manufacturing costs.
6. Study of Swiss cheese manufacturing costs.
7. Study of losses in creamery receiving rooms.
8. Study of losses in butter manufacture.
9. Study of losses in Swiss cheese manufacture.
10. Study of losses in condensed milk manufacture.
11. Study of cream hauling problems.

Miscellaneous

1. Collection of dairy statistics; charting data obtained, and interpretation of statistics.
2. Experiments in temperature control in connection with dairy manufacturing.
3. Experiments in humidity control.
4. Experiments in heat transmission.
5. Problems in refrigeration in connection with dairy manufacturing plants.

IN HOW FAR IS THE BACTERIAL COUNT OF MILK INFLUENCED BY THE DIRT CONTENT?

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Almost every one has an opinion regarding the influence of the visible foreign matter, commonly referred to as dirt, upon the bacterial count of milk and these opinions fall into two groups, the larger of which supports an old view and the smaller one a modern one.

The old view is illustrated by the fact that much of the past advice to the producer and dealer who are striving for a milk of low germ content may be summarized in the injunction, "Get it clean and keep it cold." In many of our cities, milk ordinances have been enacted setting limits to the permissible bacterial count of milk, with the avowed object of providing a clean milk supply. In some cases the authorities delegated to enforce our pure-food laws have taken the position that the presence of large numbers of bacteria in milk is evidence of filthy conditions of production or handling. Accordingly, it is natural that the general public should regard a milk which sours quickly as dirty and, therefore, objectionable from the æsthetic and sanitary standpoint.

On the other hand, the modern view has been based upon certain facts which have suggested that dirt has but slight influence upon the bacterial count. Where market milk has been scored both on its content of visible dirt and on its bacterial count, no well marked relation has been found between the dirt score and the bacterial count. Apparently the milk containing evident dirt is about as likely to have a low bacterial count as are other samples.

The importance of the keeping quality of milk has led to studies of the source of its bacterial life. It has been established that in a few cases the udder of the cow makes large additions to this bacterial life (1) but that ordinarily the udder contributes about 500 per cubic

centimeter (2). It has also been shown that in warm weather, utensils which are well washed and steamed but not promptly and thoroughly dried, when used some hours later contribute 30,000 or more per cc. to the bacterial count of the milk. (3). The morning's milk as it is delivered from the farm to the milk plant often shows a bacterial count of approximately 50,000 per cc. (4). The much higher numbers which are later found in this same milk are the result of growth. There is no known relation between the dirt content and the bacterial count due to the udder, between the dirt content and the bacteria from the well washed utensils, or between the dirt and the rate of bacterial growth in the milk. Inasmuch as udder flora, utensils, and growth seem to account for practically all the bacteria found in city milk supplies, it is hard for those holding the modern view to believe that the dirt content exerts a controlling influence over the bacterial content of milk.

The accumulation of this kind of circumstantial evidence has led to the gradual development of a new point of view regarding the relation of dirt to the bacterial count of milk. This point of view is indicated in the following quotation from Third Revision of the Standard Methods for the Sanitary Analysis of Milk as approved by the Laboratory Section of the American Public Health Association at the San Francisco meeting, September, 1920.

Because much of the dirt that appears as a visible and insoluble sediment *in milk is accompanied by relatively few bacteria in proportion to the number derived from other sources*, it frequently becomes desirable to use a test that will reveal the amount of visible sediment in the milk. For this reason the committee has included a description of the commonly used sediment test. *It is only by using this sediment test* in conjunction with the bacterial count *that it is possible to prevent the occasional approval of dirty milk.*[1]

Considering the practical importance of this matter, there is a surprising lack of data regarding the relationship of dirt to bacterial count. The old idea that the dirt content exercises a controlling influence over the bacterial life in the milk rests partly upon the fact that dirt always carries bacteria and partly upon the fact that the dirt has been long said to control the bacterial content.

[1] Italics are our own.

Any belief which is held by so large a number of intelligent people should be treated with respect, but at the same time the important relation which this matter sustains to the milk business makes it very desirable that the facts in the case be determined. The following data are submitted with the hope of furnishing a more substantial basis for the discussion of this question.

INCREASE IN BACTERIAL COUNT DUE TO DIRT FROM FAIRLY CLEAN COWS

While dirt may enter milk at any stage on its journey from the cow to the consumer, the milk is normally protected by being placed in covered cans almost immediately after it is drawn from the cow. Accordingly, the entrance of dirt, at least at the farm, is practically restricted to the milking process and the main source of dirt is the material falling from the coat of the cow.

During 1914–1915 a study was made of the bacterial count of the milk from the cows in three barns. This milk was drawn by hand in the ordinary way into small-topped milk pails, having an oval opening 5 by 7 inches. The pails had been thoroughly steamed and protected from contamination up to the beginning of the milking process. The samples for bacteriological study were taken from the pail when the milker brought it from the barn into the adjoining milk room. Examinations were also made of the udder flora of the cows. This study included 1665 samples. (For details see Bulletin 199 (5) of this station.)

In barn I, in which the general conditions of cleanliness were comparable with conditions in some certified milk barns, the bacterial count of the milk, if that from one abnormal cow be omitted, averaged about 1,000 per cubic centimeter. Since this represented the combined influence of the udder flora and of the dirt, the influence of the dirt may be obtained by subtracting the 500 per cubic centimeter which has been found to be a normal figure for the udder flora of normal cows. On the basis of this calculation, the dirt falling into the milk in this barn increased the bacterial count by approximately 500 per cubic centimeter.

In barn II the general conditions of the barn and cows were comparable with those of the better market milk dairies. Here again, the milk as it came from the barn showed a bacterial count of approximately 1,000 per cubic centimeter. The udder content of the cows was normal, and making the deduction of 500 per cubic centimeter for udder flora leaves 500 per cubic centimeter as the increase due to dirt entering the milk. The explanation of these identical results in two barns which appeared to be quite different in their cleanliness lies in the fact that in both barns the cows were well bedded and were clean and in both cases hair and dandruff from the cows fell into the milk during the milking process.

In barn III conditions were quite different. This barn had a dirt floor and no provision for drainage, and the cows were allowed to run loose in it except at milking time. Straw was added to absorb the liquid and cover the manure and the resulting accumulation became two to four feet deep before it was removed twice a year. Straw was supplied abundantly, and in the main the coat of the cows remained fairly clean, though the condition of the stable floor and, to some extent, the coat of the cows would undoubtedly have called forth a protest from a city milk inspector. The conditions of cleanliness were roughly comparable with those of ordinary dairies during the winter season. The average bacterial count of 238 samples of milk from this barn was 5,775 per cubic centimeter. As the bacteria from the udder of the cows in this barn gave a bacterial count of about 1,000 per cubic centimeter, the bacterial count due to the dirt amounted to approximately 4,500 per cubic centimeter.

EFFECT OF DIRT FROM EXTREMELY DIRTY COWS

The barn conditions already studied are representative of dairy conditions ranging from very good to rather questionable. In order to cover the subject it was desirable to study the milk produced by extremely dirty cows. It is the unwritten law of public institutions that dairy cows must be kept clean, and accordingly it was difficult to provide suitable material

for such a study. In the work already described, the cows were allowed to become so dirty as to provoke unfavorable comment.

In the winter of 1916, taking advantage of a quarantine due to a neighboring outbreak of foot-and-mouth disease, the cows in barn III were allowed to become extremely dirty. The accumulation of manure on the floor of the stable in which the cows

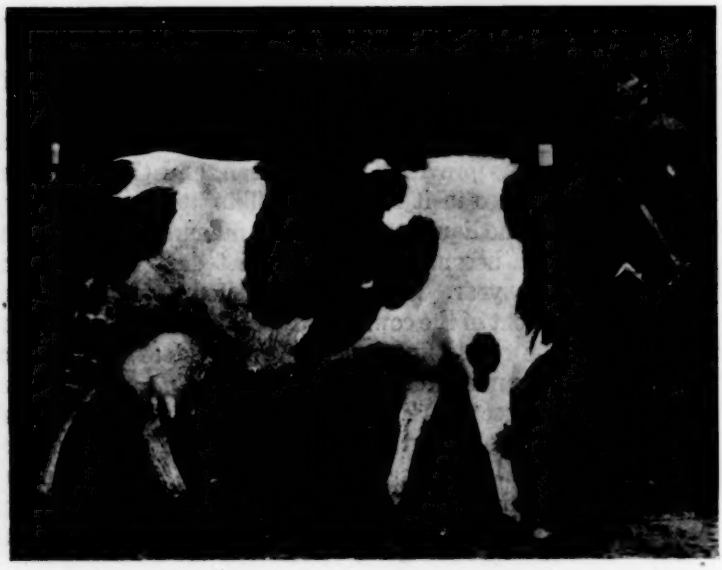

FIG. 1. SHOWING THE CONDITION OF THE COAT OF COW 1033 DURING THE PERIOD WHEN SHE WAS NOT CLEANED

were loose became about 4 feet deep. Practically no attempt was made to clean the cows for some months. Dirt and dried feces accumulated on the flanks and abdomens of the cows and they were fairly representative of extremely dirty conditions. The condition of the coat of one of these cows is shown in figure 1.

When the condition of the cows had become representative of extremely dirty conditions, the study of the milk was begun.

This study included a determination of the bacterial count and the dirt content of the milk of seven cows. The determinations of the bacterial count were made in three series of 10 milkings each, and in addition the bacterial count of the milk directly from the udder of each cow was determined at 6 separate milkings. Unfortunately the difficulties of determining the dirt content were such that it was accomplished at a total of only 24 milkings. Bacterial counts were made from a total of 252 samples.

The three series differed from each other in that in the first series of milkings from the extremely dirty cows, the milk pail was the small-topped one, with an oval opening 5 by 7 inches, used in the previous studies in barns I, II, and III; in the second series the cows were extremely dirty and an ordinary open-topped pail, having a diameter of about 12 inches, was used; and in the third series conditions were the same as in the first except that the coat of the cows had been thoroughly cleaned. The milk pails, in all cases, were carefully steamed and protected until used.

The sample for determining the bacterial count of the milk was taken from the milk of each cow as the milk came in the pail from the stable to the milk room. The dirt determinations were made from the unstrained milk, collected in eight-gallon cans. The total weight of this milk at each milking varied between 112 and 168 pounds.

Determining the dirt in the milk. A combination of sedimentation and centrifugal force was used in determining the amount of dirt. After the cans of milk had stood for eight hours, the bulk of the milk was siphoned (the first five samples were poured) through a weighed, 100-mesh to the inch sieve. The remaining milk was poured through the same sieve but collected in a glass cylinder. The cans were then rinsed and the rinsings poured through the sieve into the cylinder. The sieve was washed with water and a little alcohol to free it from milk and fat and these washings were added to the cylinder. The sieve was then dried and weighed. The material retained by the sieve was largely hair, and bits of straw, and what appeared to be scales from the skin of the cow.

Corrosive sublimate was added to the material in the cylinder as a preservative, and after the cylinder stood eight hours the upper portion of the fluid was siphoned off. The remaining material was centrifuged for half an hour, the liquid poured off, the sediment again suspended in distilled water and the centrifuging repeated. The liquid was then poured off and the sediment washed into a weighed, folded filter, dried, and weighed.

Series I. When the small-topped pail was used. In order to get information comparable with that from the earlier studies in barns I, II, and III, the small-topped pail was used in this

TABLE 1

Dirt and bacterial count from milk, drawn from dirty cows, into small-topped pails

DATE	MILK	DIRT				BACTERIA PER CUBIC CENTIMETER
		On sieve	On filter	Total	Per quart	
	pounds	*mgm.*	*mgm.*	*mgm.*	*mgm.*	
February 24, a.m.	162.1	236.6	250.7	487.3	6.5	12,734
February 24, p.m.	148.1	727.2	259.6	986.8	14.3	8,416
February 25, a.m.	167.7	518.4	66.2	584.6	7.5	12,400
February 25, p.m.	148.9	352.4	96.2	448.6	6.5	12,115
February 26, a.m.	161.1	512.7	83.8	596.5	8.0	17,896
February 29, p.m.	142.1	370.0	133.9	503.9	7.6	14,800
March 1, a.m.	158.7	435.6	82.5	518.1	7.0	19,577
Average per quart		6.2	1.9		8.1	
Average per cubic centimeter						14,000

first series of samples. The average of the bacterial count from 70 samples of the milk from individual cows averaged 12,954 per cubic centimeter. Fifty-nine samples direct from the udders of these cows gave an average bacterial count of 964. Accordingly, the bacterial count due to dirt falling from these extremely dirty cows during the milking process, into small-topped pails, averaged 12,000 per cubic centimeter.

The dirt content of the milk was determined at seven milkings, and the results of these determinations as well as the bacterial count of the milk in which the dirt was determined is given in table 1.

As shown in table 1, the dirt collected on the sieve represents the dirt falling into the milk and later removed by careful straining. It consisted of bits of straw and hay, hair, dandruff, and coarse particles. At the second milking it included a large piece of hay which made up the larger part of the material. It will be noted that the material removed by the sieve averaged 6.2 mgm. per quart of milk. The finer material which passed the sieve represents the dirt which ordinarily remains in the milk unless removed by the clarifier or similar means. In these seven tests this material averaged 1.9 mgm. per quart. The total dirt recovered from this milk from extremely dirty cows when drawn into a small-topped pail averaged 8.1 mgm. per quart, or if the milking in which the large piece of hay fell be omitted, the average would have been 7.1 mgm per quart. The bacterial count of the milk was fairly uniform, varying from 8,500 to 19,500 per cubic centimeter. It will be noted that the smallest bacterial count was from the milk containing the largest proportion of dirt, but it has already been explained that this dirt consisted of a piece of hay, which was undoubtedly low in bacterial count. Had the milk from these seven milkings been blended together, it would have had a bacterial count of 14,000 per cubic centimeter.

In this connection it should be noted that this bacterial count was made after the plates had been incubated for five days at 20°C. and two days at 37°C. instead of the single incubation for two days at 37.5°C. as required by the official methods for routine milk examinations. This longer incubation period has been used consistently in all of these studies because it gives distinctly higher bacterial counts. Accordingly, had these samples of milk been given the official routine bacteriological examination, the majority of them would have shown bacterial counts below 10,000 per cubic centimeter, which marks the upper limit for certified milk.

Series II. When the ordinary milk pail was used. In commercial dairies, under the exceptional conditions where the cows would be permitted to become as dirty as those in this study, the ordinary open milk pail would be used. Under these conditions

the maximum amount of dirt would fall into the pail. In order to measure the dirt under the worst conditions, the seven cows were milked into open-topped pails for ten successive milkings. Samples representing the milk of each gave an average bacterial count of 18,229 per cubic centimeter. Forty-six per cent of the samples gave a bacterial count below 10,000 per cubic centimeter, and there was but one sample among the seventy with a bacterial count above 60,000, which marks the upper limit for New York Grade A milk.

TABLE 2

Dirt and bacterial count from milk, drawn from dirty cows, into open-topped pails

DATE	MILK	DIRT				BACTERIA PER CUBIC CENTIMETER
		On sieve	On filter	Total	Per Quart	
	pounds	*mgm.*	*mgm.*	*mgm.*	*mgm.*	
March 1, p.m.	140.0	574.1	107.7	681.8	10.5	22,179
March 2, a.m.	162.1	871.7	108.1	979.8	13.0	9,164
March 2, p.m.	143.8	695.6	66.9	762.5	11.4	17,470
March 3, a.m.	158.0	562.7	98.4	661.1	9.0	15,959
March 3, p.m.	140.5	589.9	75.5	665.4	10.2	17,929
March 6, p.m.	149.2	1103.5	119.5	1223.0	17.6	8,250
March 7, p.m.	132.8	1029.9	271.4	1301.3	21.1	35,623
March 8, p.m.	150.7	1309.2	157.7	1466.9	16.6	22,303
Average per quart		12.4	1.8		14.2	
Average per quart omitting last three		9.5	1.3		10.8	
Average per cubic centimeter						18,244

The dirt content of the milk was determined at eight milkings and the results of these determinations as well as the bacterial count of the milk is given in table 2.

Of the dirt determinations shown in table 2, it is evident that the last three samples are abnormal. The results are given here just as determined even though the reason for the abnormality was understood at the time of determination. On these three days the milk promptly became ropy, and it was not possible to separate all of it from the sediment. The difficulty is most evident in material retained by the sieve, though the results from the filter were also affected. If these abnormal

results were included, the sediment per quart would average 14.2 mgm.; or if the calculations were restricted to the five days when conditions were normal, the average dirt content would be 10.8 mgm. per quart. The bacterial counts show that at two milkings the entire product of the seven cows had a bacterial count of less than 10,000 per cubic centimeter, and that at no milking did the count go above 36,000 per cubic centimeters. The average bacterial count for the entire 1,177 pounds of milk was 18,244 per cubic centimeter.

Series III. When the cows had been cleaned. In series I and II are given the germ count found and the dirt recovered from the milk of seven extremely dirty cows when they were milked into small-topped and into ordinary pails. The cows were dirty as a result of their lying upon an accumulation of straw and their own manure, which at the time of the study was about four feet deep.

In order to bring out more clearly the effect of the condition of the coat of the cow upon the cleanliness and the bacterial count of the milk, the coats of the cows were cleaned and all the other factors in the situation allowed to remain unchanged. For ten successive milkings these cleaned cows were milked into small-topped pails and the bacterial count and the dirt content were determined as in the preceding series. Only 15 per cent of the 68 samples gave a bacterial count of over 10,000 per cubic centimeter, and the average of all the samples was 7,165 per cubic centimeter.

The dirt content as determined at nine milkings as well as the bacterial count of the milk is given in table 3.

The coats of the cows were thoroughly cleaned before starting this series of samples. Then before each milking, the milker made some effort to remove the dirt evident upon the cow, and the resulting cleanliness of the cows was in sharp contrast to their former condition. Sufficient labor was not available, however, to keep the coats of the cows clean when they were living on the top of a manure heap. It will be noted from table 3 that at the first three milkings the dirt content of the milk steadily increased. Since this milk was drawn into small-topped

pails, the results in table 3 are directly comparable with those in table 1, the single difference being that the coats of the cows had been cleaned.

The total dirt recovered from the milk of the cleaned cows was 4.6 mgm. per quart, as against 8.1 mgm. recovered from the milk of the extremely dirty cows. Likewise the average bacterial count of 7,117 per cubic centimeter from the milk of the cleaned cows is comparable with 14,000 per cubic centimeter in the

TABLE 3

Dirt and bacterial count from milk, drawn from cleaned cows, into small-topped pails

DATE	MILK	DIRT				BACTERIA PER CUBIC CENTIMETER
		On sieve	On filter	Total	Per quart	
	pounds	*mgm.*	*mgm.*	*mgm.*	*mgm.*	
March 17, a.m.	145.6	160.6	7.6	168.2	2.5	3,490
March 18, a.m.	143.3	208.7	26.0	234.7	3.5	17,219
March 18, p.m.	128.1	210.8	54.5	265.3	4.5	5,379
March 20, a.m.	126.4	142.6	60.1	202.7	3.4	3,672
March 20, p.m.	112.4	249.8	56.8	306.6	5.9	6,473
March 21, a.m.	148.7	222.3	48.9	271.2	3.9	5,650
March 21, p.m.	134.4	415.1	79.1	494.2	7.9	6,382
March 22, a.m.	155.0	103.3	75.6	178.9	2.5	6,086
March 23, a.m.	146.7	392.9	26.1	419.0	6.2	9,108
Average per quart		3.8	0.8		4.6	
Average per cubic centimeter						7,117

milk of the extremely dirty cows. Allowing 1,000 per cubic centimeter as the bacterial count due to the udder, these results indicate that cleaning the coat of the cows resulted in a 44 per cent reduction in the dirt content and a 46 per cent reduction in the bacterial count. It chanced that two of the highest bacterial counts of the series occurred in the samples on the morning of March 18, and the average bacterial count for that milking was 17,219. The combined average for the bacterial counts of the other eight milkings was but 5,780 per cubic centimeter.

BACTERIAL COUNT OF THE DIRT FROM EXTREMELY DIRTY COWS.

The smallness of the increase in the bacterial count of the milk in these series of tests, that was due to dirt falling from the extremely dirty cows will undoubtedly be a surprise to all and perhaps something of a disappointment to those who hold that dirt is a large source of germ life in milk.

It may be suggested that for some reason the dirt from these cows did not furnish a large bacterial count. However, the amount of milk, the dirt content, and the germ count are all known with regard to each of the three series of tests, and from those data it is possible to compute the bacterial count of the dirt recovered from the milk. This may be done by computing the total germ count of the milk, subtracting the 1,000 per cubic centimeter due to udder flora, and dividing the resulting number by the grams of dirt. The data for this calculation for each of the three series are given in table 4.

TABLE 4

Bacterial count of dirt recovered from the milk

SERIES	VOLUME OF MILK	DIRT FOUND	GERMS IN MILK	GERMS FROM UDDER	GERMS FROM DIRT	GERMS FROM 1 GRAM OF DIRT
	cc.	*gm.*				
I	478,537	4.1258	6,699,610,147	478,537,000	6,221,073,147	1,507,840,000
II	327,162	3.7506	5,338,981,994	327,162,000	5,011,819,994	1,341,600,000
III	545,765	2.5408	3,884,347,760	545,765,000	3,338,582,760	1,313,980,000

The data in table 4 place the bacterial count of the dirt recovered from the milk at approximately 1.5 billions per gram. Those who are familiar with the bacterial count of milk and surface soil will at once recognize that this is a high figure. In fact it is so high that those who feel that the amount of dirt recovered from the milk was too small may suggest that this large amount of bacterial life may have entered the milk in connection with a larger amount of dirt than was later recovered from the milk.

Manifestly the most direct means of determining the bacterial count of the dirt falling from the udder and flank of the cow during the milking process is to secure some of this dry material directly from the cow and determine its bacterial count.

This plan was followed, two cows in two different barns being used for the purpose. Cow 152 in barn I had been brushed daily, and her coat showed no visible dirt. She was representative of very clean cows. Cow 1039 in barn III was an extremely dirty cow. Her condition and surroundings were the same as the seven cows in series I and II. Her flank and abdomen were partially covered with dried manure.

Neither cow was in milk, and the samples were collected by using a sterilized, open-top milk pail. Any loose bedding on the flank or udder was brushed away by hand, as is customary before milking, but the cows were not otherwise prepared for the tests. The pail was held partially under the cow, as would be done during ordinary hand-milking, and the udder mani-p ulated as though the cow was being milked. In the first two tests the manipulation was continued for seven minutes and in the three others for ten minutes. The pail was then taken to the laboratory and the visible dirt brushed out and weighed. The dirt was then mixed with a definite amount of milk and after being mixed for fifteen to twenty-five minutes, plates were prepared for determination of the bacterial count.

The results of five such determinations are given in table 5.

From table 5 it is seen that the clean and the dirty cows were quite unlike both in the amount of dirt falling into the pail and in the bacterial count per gram of dirt. In other words, the dirt from a dirty cow is not only more abundant but it is also a different kind of dirt with a much higher bacterial count per gram.

In removing the dirt from the pail during the experiment it was noted that the dirt falling from cow 152 consisted of some hair and fine dandruff. The dirt from cow 1039 was made up of considerable hair, dandruff, and many fine particles of dirt, presumably in part dried manure. Because of the distinctly different bacterial count of the material from the two cows, interest is at present centered upon the results from cow 1039, since she was a companion cow with the seven dirty cows in barn III.

It will be noticed that four tests of this cow on successive days gave widely differing results, not only in amount of dirt collected,

but in the bacterial count per gram of this dirt. While this variation is undoubtedly due in part to the varying bacterial count of the different kinds of dirt finding their way into the pail, it is also due in part to the difficulty of getting representative samples of the material in making the plates. In preparing the samples, the dirt was placed in measured amounts of milk varying from 500 to 5,000 cubic centimeters, and after fifteen minutes, with thorough shaking, samples were taken for plating within the following ten minutes. The number of samples taken, from which dilutions and plates were made, varied from two to twenty on the different days and six to nine plates

TABLE 5

Bacterial count of dirt from coats of cows

NUMBER OF COW	CONDITION OF COW	DIRT FROM MILK PAIL	GERM COUNT OF DIRT	GERM COUNT PER 1 GRAM
		gm.		
152*	Clean	0.043	766,000	17,814,000
1039*	Dirty	0.240	94,285,000	392,800,000
1039	Dirty	0.108	496,000,000	4,592,000,000
1039	Dirty	0.083	15,300,000	184,000,000
1039	Dirty	0.171	293,475,000	1,716,000,000

* In these two tests the manipulation of the udder was continued but seven minutes while in the other three the manipulation lasted ten minutes. To facilitate comparison, the amount of dirt and its bacterial count were increased to a ten-minute basis. This did not affect the final computation of bacterial count per gram of dirt.

were made from each sample. Not all of these plates could be counted, but the bacterial counts given for the four tests of cow 1039 are based upon counts from 11, 20, 13, and 46 plates respectively. The fact that in these experiments the dirt was suspended in less than one-tenth the volume of milk in which it would be suspended in ordinary milking undoubtedly added to the difficulty of getting accordant bacterial counts.

It is plain that little can be gained by considering a mathematical average of bacterial counts which vary as widely as those in table 5. At the same time it is clear that if a large number of such determinations were averaged, as was done with each of the three series of samples from barn III, it is altogether likely

that such an average would show a bacterial count for the dirt of at least 1.5 billions per gram.

Accordingly, in so far as conclusions can be drawn from such a limited number of observations, these direct examinations of the dirt falling into the milk pail from a dirty cow suggest that the visible dirt recovered from the milk in the three series of experiments was sufficient in amount to account for the accompanying increase in the bacterial count of the milk. In other words, these results tend to show that the methods employed in recovering the visible dirt from the milk recovered essentially all of the dirt.

In the case of three of these suspensions, where a known amount of dirt was suspended in 500 cubic centimeters of skim milk, advantage was taken of the opportunity to test the extent to which it is possible to recover this dirt by filtration through cotton. In each case the weight of the cotton filter after filtration and drying was found to be increased by an amount slightly in excess of the weight of the dirt added to the milk. Evidently the milk adhering tenaciously to the cotton more than offset the weight of any dirt which went into solution or passed through the cotton. As the technique employed in the case of these 500 cc. suspensions was different from that employed in removing the dirt from the larger quantities of normal milk, they throw little light upon the accuracy of the other method except to suggest that the element of solubility is not large in the case of the dirt falling into the milk from extremely dirty cows.

SUMMARY AND CONCLUSIONS

Practically all of the dirt entering the milk at the farm enters during the act of milking.

The use of a small-topped milk pail materially reduces the amount of dirt entering the milk, the reduction varying from 25 to 40 per cent.

These studies show that the weight of the dirt entering the milk during the milking process is surprisingly small. Even when the cows were extremely dirty and were milked into an open-topped pail, the dirt in the unstrained milk amounted to only about 10 mgm. per quart. When the conditions were comparable

with those of ordinary dairies and the small-topped pail was used, the dirt in the milk was less than 5 mgm. per quart. Under conditions comparable with the better class of market milk dairies and where the small-topped pail was used, the proportion of dirt was not over 2.5 mgm. per quart.

The kinds of dirt falling into the milk vary with the condition of the coat of the cow. With hand milking, the entrance of some hair and dandruff is practically unavoidable, though the amount may be reduced by regularly brushing the coat of the cow. If the flank or udder is soiled with dried manure and other dirt, some of this may find its way into the milk.

Thorough straining removes the hair, dandruff, and larger particles, which form 75 to 90 per cent of the visible dirt.

Undoubtedly some of the dirt goes into solution in the milk, but the amount was so slight that we did not succeed in measuring or even in detecting it.

The increase in the bacterial count due to dirt entering the milk varies widely with the nature of the dirt. Hair and dandruff from clean cows have much less effect upon the bacterial count than dirt from extremely dirty cows.

The germ life on dirt from extremely dirty cows gave a bacterial count of approximately 1.5 billion per gram of dirt. Under the worst conditions, when the dirt in the milk amounted to 10.8 mgm. per quart, the increase in bacterial count of the milk was about 17,000 per cubic centimeter. Under the same conditions except that the small-topped pail was used, which reduced the dirt entering the milk to 8.1 mgm. per quart, the bacterial count due to dirt fell to 13,000 per cubic centimeter.

Previous studies have shown that in warm weather the use of clean utensils which have not been promptly and thoroughly dried results in an immediate increase of the germ count of the milk varying from 30,000 to 1,000,000 per cubic centimeter. In the summer season the milk drawn in the morning and delivered from the farm to the milk plant has an average bacterial count of at least 50,000 per cubic centimeter. After the first six to ten hours, growth begins and may rapidly increase the bacterial count.

In view of these facts, it is plain that variations in the bacterial count as large as 17,000 per cubic centimeter due to dirt, at least in the summer season, will be promptly overshadowed by other factors. When the time interval permits growth, any attempt to judge of the conditions of cleanliness surrounding the production of a given sample of milk on the basis of its bacterial count becomes hopeless.

When the results of this study are properly understood, it will be clear that they can not be used legitimately as an excuse for the production of dirty milk.

These studies show that where the germ count is relied upon to protect the consumer against dirty milk, the consumer will not be protected. It is entirely possible for the dirtiest milk to pass the most stringent standards based on bacterial counts which have been established in connection with the supervision of municipal milk supplies.

While it is still an open question as to what may ultimately be accepted as the most satisfactory index for the keeping quality of milk there is no question but that when the bacterial count is properly determined it is a serviceable index for this purpose. It is not. however, an index by which the presence of dirt can be determined, for the bacteria are commonly so numerous in milk and come from so many sources other than dirt that there is no constant relation between the dirt content and the number of germs present. Such being the case, the conclusive demonstration of the uselessness of bacterial counts as a means of detecting the presence of dirt is the necessary first step toward developing methods for accurately safeguarding the public against dirty milk.

As has been repeatedly pointed out in this publication and in the report of the Committee of the American Public Health Association already quoted, if the public is to be protected against dirty milk it must be, not through attention to bacterial counts, but through attention to measurements of the dirt actually present.

The measurements herein reported are respectfully submitted as a pioneer attempt looking toward the ultimate formulation of reasonable and helpful standards for clean milk.

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THE VARIATION IN THE PER CENT OF FAT IN SUCCESSIVE PORTIONS OF COW'S MILK[1]

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The fact that successive portions of milk drawn from a cow gradually increase in fat content has long been known by the practical dairyman and recently verified by a large number of investigations (1) on man, ox, and goat. This increase in fat content of successive fractions of milk was formerly explained (2) by the action of gravity, the lighter fat rising to the top of the milk cistern and ducts, leaving the bottom milk poorer in fat. This gravity theory was discarded due to the estimations of Heidenhain (3) that the glandular capacity of the udder as determined by the difference in its volume before and after evacuation of milk is much below the volume of milk given by a cow during one milking, and his consequent inference that milking activates the secretion of milk, a large part of the milk being secreted during the process of milking. If Heidenhain's inference is correct then of course the gravity theory can not be used to explain the variation of fat in the last fractions of milk which are largely secreted during the process of milking, and the explanation current since Heidenhain's time is that the forward movement of the fatty globules is retarded through congestion and friction and come down completely only as the last portions of the milk are drawn off.

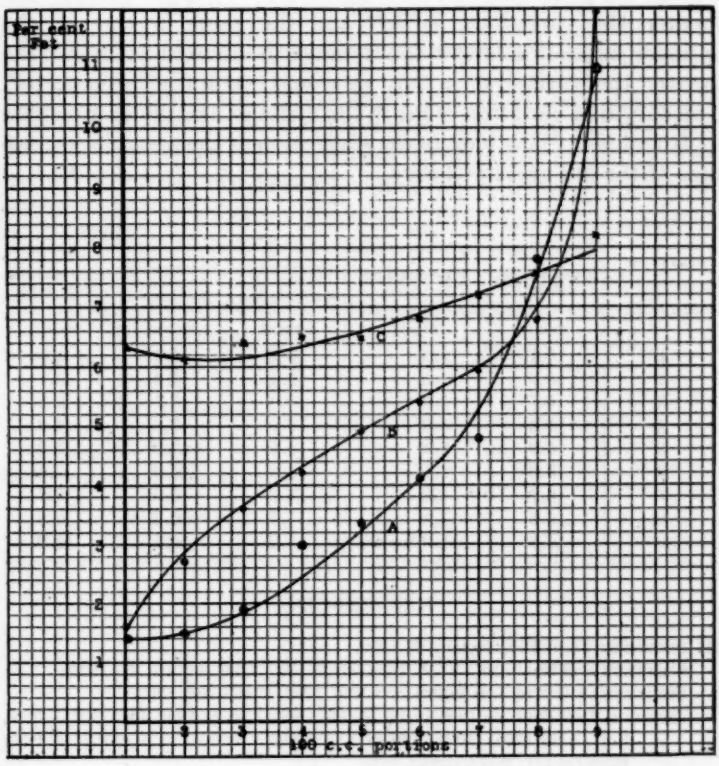
The object of this paper is to present a rather striking fact bearing on this subject which may, with further accumulation of data, contribute to an explanation of the phenomenon. The right front quarter of a Jersey cow producing about 20 pounds of milk per day was milked under the following conditions:

[1] Published with the permission of the Director of the Missouri Agricultural Experiment Station.

a. Immediately on coming into the barn from the pasture.

b. After standing quietly in the barn for two hours.

c. After standing quietly in the barn for two hours followed by a thorough massaging and manipulation of the udder for a few minutes for the purpose of "mixing" the milk within if such is possible.



GRAPH SHOWING THE VARIATION IN THE PER CENT OF FAT IN SUCCESSIVE PORTIONS OF MILK

A, Drawn from a cow after standing in the barn for two hours; B, Drawn from a cylinder after standing for three hours; C, Drawn from a cow after standing in the barn followed by a manipulation of the udder.

The milk in each case was drawn into a 100 cc. cylinder and fat determined in each of the 100 cc. fractions. For comparison determinations were made on the variations of fat in successive 100 cc. fractions of milk drawn from a 900 cc. cylinder of the usual dimensions after standing for one and a half hours and for three hours. The figure and table giving the results obtained show that within the given limits the longer the cow stands quietly, the greater the variations in fat; and the same is true of the cylinder milk—the longer the cylinder is allowed to stand the greater the variations in fat, as would naturally be expected. The curves of variation of fat in the cylinder and udder are strikingly similar. This tempts the suggestion of the possible correctness of the old gravity theory.

SAMPLE NO.	COW			CYLINDER	
	Upon coming into barn	After standing two hours	Standing two hours and manipulation	After standing one and one-half hours	After standing three hours
	per cent	*per cent*	*per cent*	*per cent*	*per cent*
1	3.1	1.4	6.3	4.4	1.6
2	3.2	1.5	6.1	5.4	2.7
3	4.7	1.9	6.4	5.7	3.6
4	5.4	3.0	6.5	5.8	4.2
5	5.9	3.4	6.5	5.9	4.9
6	6.6	4.1	6.8	6.0	5.4
7	6.9	4.8	7.2	6.0	5.9
8	6.5	7.8	7.5	6.3	6.8
9	6.8	11.0 (app.)	8.2	6.7	12.0

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MILD PRODUCTION OF YOUNG COWS COMPARED WITH THAT OF MATURE COWS

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The question is often asked as to how much more milk will a mature cow yield than a two-year-old cow with her first calf. In other words, if a heifer produces 6700 pounds of milk and 360 pounds of butter fat during her first year's milking, how much will she yield as a mature cow, and at what age will she mature, or at what age will she produce the largest quantity?

To determine this matter I studied the yearly official test records of 865 Jersey cows, so my work relates only to that breed, although it holds good in a general way for all dairy breeds.

The records are as follows:

Production of young cows compared with that of mature cows

AGE OF COW	NUMBER OF COWS	MILK	PER CENT	BUTTER FAT	PER CENT
year		*pounds*		*pounds*	
1	86	6,267	68	337	71
2	278	6,707	74	359	73
3	126	7,496	82	399	81
4	112	8,231	91	449	94
5	91	8,222	91	441	92
6	60	8,490	94	460	96
7	47	9,029	100	477	100
8	29	8,755	97	462	97
9	25	8,718	97	476	100
10	11	8,887	98	464	97

From the above table it is found that a heifer that produces 6700 pounds of milk and 360 pounds butter fat as a two-year-old will yield 9000 pounds milk, and 480 pounds butter fat as a mature cow, at seven years of age. But she becomes over 90 per cent as efficient at four years old, or practically mature with the third

calf. And apparently the cow will hold her maximum efficiency through her tenth year.

We find also from this table that young cows gain an easier entrance into the Register of Merit than old cows, and the same is true with all dairy breeds. To prove this statement we will call attention to the fact that six-year-old cows exceed two-year-old cows by 101 pounds fat, or by 23 per cent, while the standard for entrance into the official test book has a difference between these ages of 110 pounds (250 pounds for two year-olds and 360 for five years and over) or 30 per cent. To state it differently a two-year-old excels her requirement by 30 per cent, and the six-year-old one excels hers by only 22 per cent. But the error is not a serious one.

A METHOD FOR DETERMINING LIME IN DAIRY PRODUCTS

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In the course of studies upon the lime content of milk, it was found very desirable to have a simple and accurate method for making this determination. The following method was devised to fill this want.

DESCRIPTION OF METHOD

Two variations of the method are possible:

(1) Measure or preferably weigh the samples into clean Babcock test bottles. In all cases except when testing whole milk, add to the bottle sufficient distilled water to bring the total weight up to 18 grams. Mix samples with the water in the bottle very thoroughly. Now add slowly with constant shaking about 15 grams C. P. sulphuric acid; centrifuge for about ten minutes. Add sufficient distilled water to float off the fat. Centrifuge until the last visible traces of fat are gone, adding additional water if this might be required. Pour the solution into a beaker, and wash out the bottle with three successive small portions of distilled water. Add two volumes of 95 per cent grain alcohol, and allow to stand over night. Filter, using preferably, a Gooch crucible with asbestos. Wash the precipitate by decantation, using grain alcohol. Dry thoroughly. Ignite at a moderate temperature, to a constant weight. If a filter paper is used, dry the precipitate in the filter and ignite together.

(2) Transfer to a beaker the residue remaining in a Mojonnier fat extraction flask at the end of a fat extraction. Neutralize the ammonia carefully with C. P. sulphuric acid. Add 10 cc. in

addition to that required for neutralizing. Add two volumes of 95 per cent grain alcohol, and allow to stand over night. Proceed as under (1).

SIZE OF SAMPLES RECOMMENDED

The size of sample to use can be varied with the method employed. Table 1 gives the amount recommended under the two methods. Slight variations will not effect the accuracy of the results.

TABLE 1

Weight of sample recommended

PRODUCT	BABCOCK METHOD	MOJONNIER METHOD
	grams	*grams*
Whole milk, skim milk, butter milk, and whey.....	18	10
Evaporated milk, plain condensed whole and skim milk, ice cream mix, and cream.....	9	5
Milk chocolate, cheese, malted milk, whole and skim milk powder, and butter.....		1

EXPERIMENTAL EVIDENCE UPON THE ACCURACY OF THE METHOD

Ten grams of gypsum were heated to red heat. Weighed samples of this were ignited with filter paper, and found upon re-weighing to have undergone no change in weight.

In another experiment a sample of gypsum was treated with sulphuric acid diluted 1–5, decanted, filtered, washed, dried in electric vacuum oven, and ignited to constant weight. To about 0.1000 gram portions of this ignited product was now added 17 cc. of distilled water; 17 cc. of C. P. sulphuric acid, and after cooling, 100 cc. of 95 per cent alcohol. After standing over night, the precipitate was filtered, dried, ignited and weighed. The samples showed no loss in weight.

RESULTS OBTAINED BY THE ABOVE METHOD

The results obtained by means of the above method in the case of different dairy products are given in table 2.

The method does not apply in the case of sweetened condensed milk or other products containing large amounts of sugar, on account of the solubility of calcium sulphate in sucrose solutions.

TABLE 2

Lime content of dairy products as found by above method

TEST NUMBER	PRODUCT	PER CENT CALCIUM OXIDE		OPERATOR
		Original	Duplicate	
1	Whole milk	0.122	0.136	Author
2	Evaporated milk	0.284	0.276	Author
3	Evaporated milk	0.306	0.302	Author
4	Evaporated milk	0.344	0.340	Author
5	Evaporated milk	0.364	0.361	Author
6	Evaporated milk	0.288	0.289	Author
7	Evaporated milk	0.357	0.354	Prof. H. C. Troy
8	Evaporated milk	0.371	0.364	Prof. H. C. Troy
9	Whole milk	0.141	0.141	Prof. H. C. Troy
10	Powdered skim milk	1.410	1.420	Prof. H. C. Troy
11	Butter milk	0.159	0.156	H. J. Liedel
12	Ice cream mix	0.195	0.188	H. J. Liedel
13	Cheese		0.969	H. J. Liedel

CONCLUSIONS

The method described can be used to determine the lime content of all dairy products excepting those containing large amounts of sucrose. It is simple and accurate.

OPEN FORUM

The Biggest Problem Confronting Our Dairy Industry: Can the American Dairy Science Association Offer a Solution for It?

I do not hesitate to say that the biggest problem confronting the dairy industry is the improvement of the quality of our dairy products, especially our butter and cheese. Nor is there any doubt in my mind that the American Dairy Science Association can offer a solution for this problem if its members will put their best thoughts on the problem and devote their best efforts to its solution. There can be no doubt, for who should be better able to find a solution for this problem than those members of this Association who are daily dealing with the research, commercial and economic aspects of the dairy industry?

Considering the problem analytically from the standpoint of the fundamental, psychological and economical principles involved in its solution, we must agree that it can be solved in part if not in its entirety.

THE FIRST FUNDAMENTAL PRINCIPLE

The first fundamental principle involved is economic and has to do with the producer. If he is to be expected to produce a better quality of milk or cream from which a higher quality product can be made, he must be offered an incentive to do so and he must be rewarded for doing so. Economic results are determined by economic conditions. Is there a demand at the present time for a larger quantity of butter and cheese of higher quality than is now produced? If this demand was filled, could sufficient price be obtined for the additional quantities of high quality product so that the farmer would be rewarded for his part in helping to produce it? These questions must be answered in the affirmative, else there can be no possible incentive offered the farmer, and without an incentive to do better, to produce better, very little progress or improvement can be expected.

Our nation today is the creditor nation of the world, and our purchasing power is larger than that of any other nation. We should have here the best market in the world for dairy products and especially

dairy products of high quality, for only consumers of high purchasing ability are able to buy high quality dairy products. If we do not produce these products of high quality, then limited supplies will make for high prices for such products, unless foreign dairy countries send their high quality products here to supply this demand. Surely we can afford to produce and supply our own markets with these high quality products if other countries can do so. If we can't, then we must expect to obtain our food stuffs largely from foreign lands, because, when dairying as a business fails and is unprofitable in this country, then many other lines of agricultural production will also fail; for what phase of agriculture can be made more profitable than dairying when it is efficiently conducted? Our dairy industry must always compete as a business with every other kind of farming suited to dairy sections, and the dairy industries of all foreign countries must do likewise. We are told we should consume twice the dairy products we are now consuming, that proper national advertising should sell this additional amount of dairy products when we produce the quality product, sell it on a quality basis and tell the consumer why he should buy twice the amount he is now buying.

A SECOND FUNDAMENTAL PRINCIPLE

Confidence is the basis of most business dealings. If you have little confidence in the business methods of a person, you are not inclined to increase or enjoy your business dealings with that person. Business dealings are mostly prompted by a mutual benefit to be derived and a certain amount of personal satisfaction which can hardly be classed as mutual benefit. It is regarded generally that the nearer the business dealings can be placed on a fair and equitable basis, the greater the personal satisfaction obtaned and the farther the mutual business relations will be extended. In fact, confidence is promoted by fair and equitable business dealings.

A BASIS FOR EQUITABLE DEALING IN DAIRY PRODUCTS

The most equitable basis for dealing in dairy products is that of quality—that is, the producer's product would be paid for on a basis of quality and the products should be sold to the consumer on a similar basis. Grades and standards for quality are essential for such equitable buying and selling methods. Today, such do not exist, or if they exist they are not used as they should be; therefore, a great weakness exists in our present dairy marketing system and a serious handicap is placed

upon improvement in the quality of our product, and upon increased consumption of our products.

Standards of quality must be established and our products must be marketed upon a quality basis, for it is fundamental to fair and equitable dealing in dairy products and to progress in our industry.

CREAM QUALITY AND BUTTER QUALITY MUST BE CORRELATED IN THE STANDARDS AND GRADES OF EACH

If cream is bought on a quality basis, the grades or various standards of quality for cream should be directly correlated to the grades or standards of quality of the butter resulting from the various grades of cream. Can such be established? That remains to be determined. Here is a problem for the practical butter makers and cream graders to study, as well as for the research investigator. A first and necessary step in such a study is a definitely established standard for the various scores or grades of butter, as has been worked out by the Dairy Section of the Bureau of Markets of the United States Department of Agriculture and which is fully described in Service and Regulatory Announcements No. 51, entitled "Rules and Regulations for the Inspection of Butter Under the Food Products Inspection Law." Copy of this bulletin may be secured upon request of the United States Department of Agriculture. With this standard clearly in mind, careful and thorough studies should be made of the quality of cream require to produce these grades or qualities of butter, and especially of the various factors or characteristics of the cream, their degree of variation and the effect of these degrees on the quality of the resulting butter.

TENTATIVE GRADES OF CREAM

The following is a tentative basis for establishing grades for cream, in which a correlation is sought in the grades of cream of certain scores and the grades or scores of butter resulting from the churning of the various grades of cream. These grades are merely suggestive of what ultimately should be produced. They are not the result of any definite laboratory experiments or investigations such as are necessary for the proper correlation of cream and butter quality with definite correlated standards of quality for each.

Tentative grades for cream

Ratings for each factor considered

Flavor	45
Acidity	25
Body	10
Richness	10
Foreign material and container	10
Total	100

GRADES	FLAVOR, 45	ACIDITY, 25	BODY, 10	RICHNESS, 10	FOREIGN MATERIAL AND CONTAINER, 10
Grade 1-A 94 or above	Very clean and pleasing	Sweet	Perfect	Above 18 per cent fat	Perfect
Grade 1 Above 92..	Clean and pleasing	Under .30	Smooth	30 per cent fat	None and clean and sanitary
Grade 2 90 to 92...	Fairly clean yet palatable	Under .45	Smooth	25 per cent fat	None and clean and sanitary
Grade 3 88 to 90...	Slightly objectionable	Under .60	Slightly defective	20 per cent or above	Slight foreign material and unsanitary container
Grade 4 83 to 88...	Strongly off flavor	Over .60	Very defective	18 per cent fat or above	Noticeable effect of either or both foreign material and unsanitary container
Grade 5 Below 83..	Foul and wholly undesirable				Excessive foreign or very unsanitary container

The above outline is wholly tentative and is intended to suggest merely a possible basis for study. The use and application of such a basis of grading in practical commercial work would necessarily have to be established and governed by carefully worked out rules and regulations in which the number of points to be cut for defects would be clearly established for each defect. Such rules and regulations can not be arbitrarily established. They must be determined by careful investigation and due consideration to all economic factors involved, especially from the standpoint of relation of defect in cream to market grade of resulting butter and market value of it.

THE USE OF STANDARD GRADES OF CREAM BY CREAMERIES

Presupposing that creameries graded their butter and so handled it that the grade or quality of it was known, possibly branding it on the package, and it was sold to the consumer on a quality basis of 87 score, 89 score, or 93 score, what would be the result if the creamery bought cream from producers on a corresponding quality basis? If each of the four grades of cream purchased were churned separately, it would be a simple matter. Each grade of cream would be paid for according to the market value of the resulting quality of butter. And this would be but logical and would promote fair and equitable business dealing with the farmers. The spread in price between the grades would be determined by economic conditions and not on an arbitrary basis which might be quite unfair and unreasonable, therefore unsatisfactory. The use of a quality basis in buying cream would offer an incentive to the producer of low quality and provide a reward to the producer of high quality cream. It would establish a basis for fair dealing and beget confidence in buyer and seller. On such a basis of dealing, mutual benefit to buyer and seller would be fairly assured.

If, however, all four grades of cream were churned together what would be the result? Would it be practically identical with the churning of each grade separately if the price paid for each grade of cream were based on the market value of the resulting quality of butter made from each grade? An example will illustrate the possible practical working out of this proposition.

Assuming a creamery is able to pay the same price per pound for butter fat that it receives for butter and butter is quoted as follow: 87 score 37 cents; 89 score 40 cents; 91 score 42 cents; 93 score 43 cents, and that a creamery receives 100 pounds butter fat in 87 score cream, 200 pounds butter fat in 89 score cream, 200 pounds butter fat in 91 score cream and 300 pounds butter fat in 93 score cream, it would then pay for the cream the following prices:

100 pounds butter fat, 87 score cream at 37 cents	$37.00
200 pounds butter fat, 89 score cream at 40 cents	80.00
200 pounds butter fat, 91 score cream at 42 cents	84.00
300 pounds butter fat, 93 score cream at 43 cents	129.00
800 pounds butter fat bought for	$330.00

Average cost per pound butter fat, 41¼ cents. Allowing 20 per cent overrun, there would be produced 960 pounds of butter which should have an average sorce of 90.75, established as follows:

100 × 87	8,700
200 × 89	17,800
200 × 91	18,200
300 × 93	27,900
800	72,600

960 pounds butter of	90.75	Score
960 pounds butter scoring 90.75 at 42 cents per pound		$393.20
Cost of 800 pounds butter fat		330.00
Difference		$63.20

Difference to cover cost of manufacture equals $63.20 or 6.6 cent per pound butter made. This is a purely theoretical case and it would be interesting to know how it would work out in practice. Who can say that it could not be worked out? If it could not, could a practical basis of grading cream be established and a practical method of applying such a basis to the buying of cream be worked out?

Here is a big problem, to the solution of which the members of the Dairy Products Section of the American Dairy Science Association can well afford to give their best thought and effort, for upon its solution is dependent the future quality of American creamery butter.

ROY C. POTTS,
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REVIEW OF DAIRY LITERATURE

A New French Dairy Journal

Le Lait is the name of a new French journal relating to the dairy industry. It is published at No. 2 Quai Chauveau, Lyon, France. Prof. Chas. Porcher, a distinguished author and investigator, is the editor-in-chief, and he is assisted by a corps of collaborators from various parts of Europe. The subscription price is 35 francs per year. The plan of the publishers is to issue not less than ten numbers per volume, one volume to appear each year.

The aim of the editors is principally twofold. First, to use *Le Lait* as a medium for the dissemination of knowledge of the dairy industry from numerous view points including both scientific and practical problems, covering a wide range of subjects. From this standpoint, it will prove of worldwide interest and it should find readers wherever the dairy cow is kept. Second to use *Le Lait* as an organ for encouraging the development of the dairy industry in France, and also the use of more milk and milk products among the French people, all of which are most worthy aims.

The high quality of the first number gives good promise that it will in the future reach the mark set for it by its publishers. The dairy industry, the world over owes a great debt to France. The discoveries of Pasteur practically applied in the so-called pasteurization of milk have made his name a household word especially in the United States. The homogenizer is another French invention that has brought great benefit to the dairy industry. *Le Lait* is destined to increase our debt still more. It is hoped therefore that the latter will receive from the United States such moral and financial support as may help to insure its success.

T. Mojonnier.